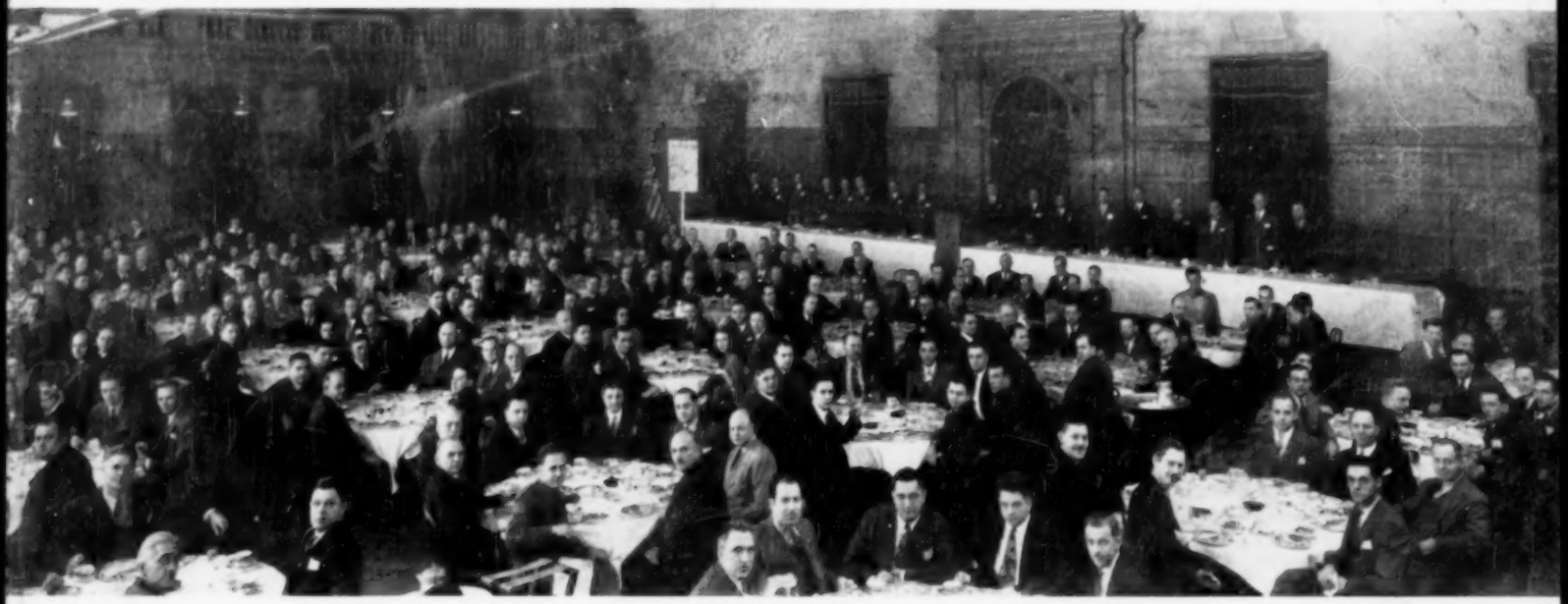
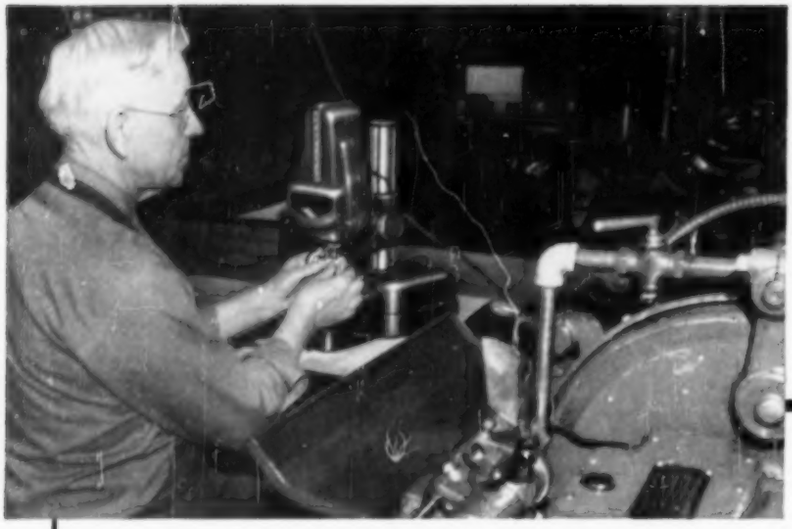
Industrial QUALITY CONTROL

VOL. III MARCH, 1947 NO. 5



The big banquet hall of the Rochester Chamber of Commerce was filled for the dinner meeting of the Third Annual Rochester Clinic. The speaker, Mr. Joseph Juran, is standing immediately at the left of the rostrum. Mr. Halsey Kent, President of the Rochester Quality Control Society, is behind the rostrum, and at his left is Mr. George D. Edwards, President, American Society for Quality Control.

AMERICAN SOCIETY FOR QUALITY CONTROL



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chek with Sheffield on "Measuring at the Machine"

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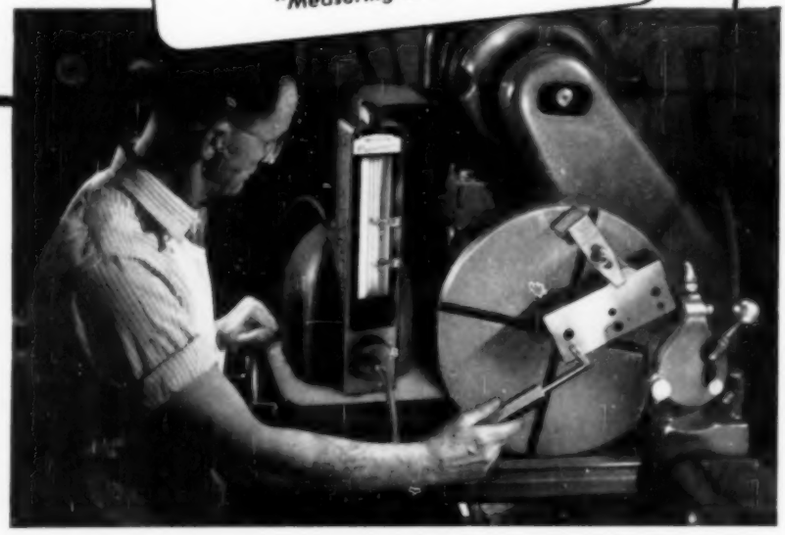

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FUTURE MEETINGS of LOCAL SECTIONS

Delaware Section—at Wilmington

May 1: "The Future of Quality Control," George D. Edwards, President, American Society for Quality Control.

Northeastern Indiana

May 14: "Sampling," Keith E. Ross, General Electric Co.

Philadelphia at Temple University

May 16: "Statistical Quality Control and What It Means to Production and Inspection," Lee Goulden, Director, Quality Control Engineers of Philadelphia.

Chicago Section, Educational Series At Northwestern University

April 16: "Theory of Probability and Its Practical Application to Methods of Sampling," A. G. Brooks.

May 21: "Use of Sampling Tables, Dodge-Romig, Army Ordnance, Navy Acceptance, and Others," Jack L. Shafer.

June 18: "Explanation and Use of Sequential Analysis," A. R. Jackson.

Quality Control for the Timken Detroit Axle Company

The Wisconsin Division of the Timken Detroit Axle Company, located at Oshkosh, Wisconsin, has recently begun a plant-wide installation of statistical quality control procedures. During the week of January 20, 1947, three classes per day were conducted by Mr. Walter S. Oliver, Assistant Quality Control Manager of the Timken Detroit Axle Company. The classes were attended by 64 persons including all of the executive and supervisory personnel who will be connected with the operation of quality control in the plant. The entire program was detailed by Mr. R. Welch, Quality Control Manager of the Wisconsin Axle Division. The program has the full support of the factory manager, Mr. Charles Billberg, and should prove to be a marked success on the strength of the plant-wide interest and enthusiasm with which it has been undertaken.

Industrial Quality Control

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COST OF BACK ISSUES

Most back issues can still be supplied individually at $1.00 each, but certain issues are now available only in complete volumes.

Volume I, which includes the July, 1944, September, 1944, November, 1944, January, 1945, March, 1945, and May, 1945, issues, is available at a price of $5.00. Volume II, which includes the July, 1945, September, 1945, November, 1945, January, 1946, March, 1946 and May, 1946 issues, is also available at a price of $5.00.

Research and Training in Industrial Statistics for the Future*

S. S. WILKS

PRINCETON UNIVERSITY

1. The Wartime Growth of Statistical Quality Control.

The growth of industry's interest in statistical quality control methods during the war surpassed all expectations for those who had, for years, urged the adoption of these methods as tools for improving the efficiency of mass production. How does one account for this great wartime outburst of enthusiasm? The answer is to be found in the fact that with the tremendous requirement of war material, thousands of manufacturers were faced with the necessity of making new and different products in great quantities as rapidly as possible. Many of these manufacturers pursued every means at their disposal to get their production under way and to maintain a level of quality acceptable to Army and Navy procurement agencies. Many of these procurement agencies, particularly for ordnance, set up acceptance sampling procedures for deciding whether to accept or reject lots of material. Some manufacturers found that large percentages of their output would not meet these acceptance sampling requirements. They simply needed to improve the quality of their products. Many of them turned to statistical process control procedures based on the Shewhart quality control charts and found them immediately effective in detecting the presence of assignable causes of excessive variation in important quality characteristics of the products.

*Presented at a joint dinner meeting of the Metropolitan New York Section of the American Society for Quality Control and the Acceptance Sampling Conference of the Newark College of Engineering, on December 13, 1946.

British manufacturers, hard pressed for maximum production of war material before the United States had seriously embarked on war production, came to a fairly general recognition of the value of statistical quality control methods about two years before American manufacturers did. It is true that there was interest in these methods in scattered companies in both countries before the war, but the interest did not become general until large numbers of manufacturers were faced with the problems of war production.

2. The Training of Quality Control Personnel During the War.

By making a study of the wartime development of the quality control situation in England up until the latter part of 1942, the Committee on Applied Mathematical Statistics of the National Research Council anticipated that there would be a similar development in the United States, with about a two-year lag. The foremost problem in this situation which had been experienced in England was that of developing personnel who could introduce and operate statistical quality control methods in industry. The number of individuals who knew anything about the subject in England before the war was totally inadequate to meet the wartime demands. The solution decided upon in England was to set up a group of experts in the Ministry of Supply who would be on call by war plants to visit such plants for varying lengths of time and install the procedures, giving enough instruction to personnel on the spot to keep the work going. In addition to the work of this Ministry of Supply group, conferences, lectures, and brief courses were organized in various war production centers in England to describe the methods and illustrate their application.

In considering the probable wartime growth of statistical quality control methods in this country, it was obvious to the National Research Council Committee that the personnel problem here would be even greater than it was in England. It was the Committee's conclusion that the only feasible way to handle the personnel problem in the United States was to urge that a program of short intensive courses in quality control be given in war production centers throughout the country to train production engineers and others closely concerned with war production. There was no hope of teaching more than just enough of the rudiments of statistical quality control methods in such courses to enable those taking the courses to install quality control procedures in the simpler and most troublesome spots in the manufacturing process in a given plant. A prototype of such a course had, indeed, been successfully carried out under the sponsorship of Stanford University in the middle of 1942. It was clear that there were not enough qualified personnel to form an adequate central group analogous to the Ministry of Supply group in England. All of the experienced personnel were already committed to important full time quality control work for their own companies or for the Army and Navy. Accordingly, the National Research Council Committee proposed to the Office of Production Research and Development (OPRD) of the War Production Board, early in 1943, that it sponsor a nationwide program of short intensive

courses of the type which had been tried out at Stanford University. The proposal was accepted by OPRD and a plan was worked out whereby the courses were administered by the Engineering, Management and War Training Program of the United States Office of Education through various universities over the country under the general supervision of OPRD. The program was under the direction of Professor Holbrook Working of Stanford University, who was later assisted by Professor E. G. Olds of the Carnegie Institute of Technology. Under this program 34 eight-day intensive quality control courses were given in approximately 25 cities throughout the country to a total of nearly 2,000 individuals representing some 800 industrial organizations. An additional 1700 industrial executives and others concerned with war production attended special one-day conferences in connection with these courses.

These courses are well known and there is no need of attempting to describe them in detail here. It should be pointed out that nearly all of the quality control experts of the country participated in these courses at one time or another by giving lectures and describing their experience with quality control problems. Thus, the task of training personnel in the United States in the wartime use of some of the simpler statistical quality control techniques was a large cooperative enterprise carried out within a very limited time schedule.

3. The Continuing Interest in Statistical Quality Control.

It is obviously impossible to produce a professional quality control engineer in an eight-day course. All that anyone could hope for was to stimulate the individuals taking the course to begin thinking statistically about some of their problems and to show them how to use some of the control chart techniques and acceptance sampling plans on a few simple production problems. There are probably very few if any individuals who will not grant that the courses more than satisfied this criterion. The fact that individuals taking these courses organized themselves into more than twenty local groups throughout the country for the purpose of meeting regularly to discuss new problems and applications of quality control procedures is evidence of a continuing dynamic interest which goes far beyond their wartime enthusiasm for the methods. Furthermore, the fact that these groups, together with the cooperation of the relatively few longstanding professional quality control engineers of the country have organized themselves into the American Society for Quality Control is evidence of the confidence of everyone in the national importance of industrial quality control work and in the value of the ultimate professional status of the quality control engineer in American industry. The Society and its local chapters are making great strides in establishing this professional status.

At the present time there can be no doubt that there is wide recognition in industry of the continuing importance of statistical quality control methods. It is not necessary to describe here the many ways in which these methods contribute to the efficiency of modern mass production technology. This has been done many times already, and in many cases in terms of dollars and cents. Literally hundreds of articles have been written to show how the methods have been applied in various industries and what has been accomplished by their application.

4. The Need for More Basic Statistical Training for Engineers.

If one had to make a summary statement of what really happened in statistical quality control in this country, and in England for that matter, he would have to conclude that it actually took a war to demonstrate that the methods, when applied on a wide scale, constitute an important national resource. It is unfortunate that the methods were not gradually introduced into industry over a fairly long period of time, so that there would have been an opportunity for the proper development of highly qualified engineering personnel to put them into effect and to operate them accordingly. As things now stand, the engineering schools of the country are just beginning to realize their responsibility in providing training for this important work. It will take a number of years for them to evolve a curriculum which can effectively provide the required training. One of the main difficulties is the fact that probability and statistical training of the type required should permeate the training of engineers in all of the various engineering fields. The statistical problems which the future engineer will encounter will cut across the traditional engineering lines. Therefore in order that he may be properly equipped to deal with many of these problems the engineer should have a fairly broad statistical training which not only covers statistical quality control methods as the term is now understood, but also includes the design of experiments, analysis of variance, and other topics. Accordingly, statistical training has to be built into the training of engineers, similar to the way in which calculus and differential equations are now made a part of their training. This means that at least one basic course in probability and statistics must be inserted into an already crowded engineering curriculum. The problem is further complicated by the fact that there are very few engineering professors who are now qualified to teach such a course. The plain fact is that the probability and statistical concepts which are so fundamental in our modern mass production technology have been, in general, foreign to engineering thinking.

5. Immediate Needs for Training in Industrial Statistics.

Until the engineering schools throughout the country have had time to adjust their curricula to meet the requirements of statistical training of future engineers, which is now being demanded by industry, some arrangement must be made for providing the necessary training for key personnel already in industry and for those who will be in industry before the engineering schools are able to adjust their curricula to give the training. Probably the most effective way to begin providing this training is for the few engineering schools which now have qualified teachers to take the initiative and arrange courses or conferences on various topics in industrial statistics for

men of industry in their own localities. This, of course, is what was done during the war in connection with the eight-day courses. But these engineering schools now have an opportunity to do a more thorough and leisurely job of conducting training in industrial statistics. The series of eleven 5-hour conferences on acceptance sampling sponsored by the Newark College of Engineering is an excellent example of the type of conference which should be conducted in industrial centers all over the country.

There are other topics in statistical methodology which have wide applicability in industry and which may soon be ripe for conferences of this type. Analysis of variance and design of experiments are examples. It is a responsibility of the engineering schools of the country to take the lead in seeing that methods such as these, which have proved their effectiveness in many fields, are introduced into industry.

6. Other Fields of Industrial Statistics.

Thus far the discussion has centered on what seems to be a fairly short-range problem in industrial statistics, namely that of training enough personnel to meet the present and immediate future requirements of industry. The industrial statistics which was carried on during the war and which is going on now is directed toward the development of personnel to deal primarily with problems of inspection and process control. Highly standardized statistical techniques — control charts and acceptance sampling plans — exist for a great majority of these problems. An enormous amount of important work remains to be done in the dissemination of information about these techniques and their application. This work will be carried forward by engineering schools, by means of in-plant courses, and by meetings of the American Society for Quality Control and its local chapters.

But it is necessary to look beyond the present activity and try to anticipate trends and requirements in industrial statistics in the years ahead. The statistical approach to problems has great versatility. It is only by showing some concern now about other large fields of potential application of statistical methods in the overall industrial process that there can arise an orderly development of these fields—as contrasted to the rather hectic development of statistical quality control work during the war. There are many categories of the overall industrial process in which certain problems are fundamentally of a statistical character and which have hardly been touched. By the overall industrial process is meant the process which begins with raw materials, research and development, and extends all the way through to sales and the analysis of consumer reaction.

Some statistical work, of course, is being done in these categories. For example, in research and development work, statistical methods are used in the analysis of materials and of results on repeated tests of apparatus in order to get a clear picture of the behavior of materials and of the characteristics of apparatus design. In research and development work on consumer products such as automobiles, electrical appliances, food and clothing, there are abundant opportunities to utilize important information which can be supplied only by a sample of consumers, or potential consumers, themselves. Sample surveys of potential consumers are already being widely used to provide useful information on the size and characteristics of the market for a given product. To get reliable information of this type requires the application of careful sampling, interviewing, measuring, and recording techniques and apropriate statistical analysis of the results. Furthermore, after the products are designed, developed, manufactured, inspected, and sold to consumers, samples of these same consumers are capable of furnishing valuable information to the manufacturers on the performance of their products out on the real testing field; namely, the field of consumers. Consumer research of this type is unquestionably a very fertile field in which the manufacturer should concentrate more of his attention in the future. It is only by consumer research that he can keep in close touch with the users of his product and know at all times where his product stands and what to do to improve its position. The main problem in consumer research is one of devising ways of getting the information reliably from consumers or potential consumers and subjecting it to appropriate statistical analysis. Work of this type is already being done, but the great bulk of the applications are yet to come. About a year and a half ago, the National Research Council and the Social Science Research Council set up a joint committee to bring together some of the results which have been achieved to date on sampling, measuring, and interviewing techniques as applied to consumer research and related fields. At present, a project is in progress on sampling techniques. Results of this project should be very useful for sampling problems in consumer research. Other projects dealing with interviewing procedures, and consumer panel methods are under consideration. It will be only a few years before some of these methods are standardized in the same way that quality control charts and acceptance sampling plans are standardized at present. When this happens, wide application of the methods can be expected to follow.

Again, one finds many problems arising in the control of inventory, the selection of personnel, sales analysis, pricing policy, and other phases of the overall industrial process, which require a statistical approach in order to be able to make any kind of an objective investigation. Too often these problems have been handled by guesses and hunches. In an age in which there have been plenty of margins to spare, it has been safe to handle such problems on this basis. But these margins are being steadily trimmed and sooner or later all such problems will have to be subjected to closer and more systematic analysis.

7. **Military Operations Research and its Implications for Industry.**

At this juncture it seems appropriate to describe briefly a wartime activity, known as **operations research** (and also by other similar names) which can be expected to have a peacetime analogue within a few years which might be called **industrial operations research.** British and American groups of scientific personnel were organized during the war and were assigned to Army and Navy commands in various theaters of operation for the purpose of making analyses of the performance of men, equipment, and tactics under combat conditions. These groups consisted mainly of actuaries, biologists, chemists, engineers, mathematicians, physicists, psychologists, and statisticians. The groups carried out hundreds of analyses on the basis of data collected in the course of military operations. They presented the results of the analyses and made recommendations to the commanding officers and members of their staffs. As a result of actions based on this activity many improvements were made in the training of men, in the design of equipment, and in the tactical employment of men and equipment. The fundamental tools in all of these studies were mathematical and statistical analysis. The initiation of these groups into the various commands early in the war was marked by reticence, skepticism, and suspicion on the part of the military men. They were unable to imagine what men like these, attached to a military command, could possibly contribute to the war effort. But as the war progressed the situation between these civilians and the military thawed out, and the scientists won the confidence and high praise of the military leaders for the way in which they, by their methods of systematic analysis, were able to locate causes of trouble, assess their seriousness, and bring them to the attention of the military authorities. The official attitude of the United States Navy towards the role played by operations research in wartime Naval operations is perhaps nowhere more effectively stated than in Section VII., of Admiral Ernest J. King's final official report entitled: **United States Navy at War** released durthe spring of 1946:

> "The complexity of modern warfare in both methods and means demands exacting analysis of the measures and counter measures introduced at every stage by ourselves and the enemy. Scientific research cannot only speed the invention and production of weapons, but also assist in insuring their correct use. The application, by qualified scientists, of the scientific method to the improvement of Naval operating techniques and material, has come to be called operations research. Scientists engaged in operations research are experts who advise that part of the Navy which is using the weapons and craft — the fleets themselves. To function effectively they must work under the direction of, and have close personal contact with the officers who plan and carry on the operations of war . . .
>
> "Operations research, as it has developed, falls into two main categories: theoretical analysis of tactics, strategy and equipment of war on the one hand; and statistical analysis of operations on the other. Each type of Naval operation had to be analyzed theoretically to determine the maximum potentialities of the equipment involved, and the probable reactions of personnel, and the nature of the tactics which would combine equipment and personnel in an optimum manner. Action reports, giving the actual results obtained in this type of operation, were studied in a quantitative manner in order to amplify, correct, and correlate closely the theoretical analysis with what was actually happening on the field of battle. The knowledge resulting from this continued cross-check of theory with practice made it possible to work out improvements in tactics which sometimes increased the effectiveness of weapons by factors of three to five, to detect changes in the enemy's tactics in time to counter them before they became dangerous, and to calculate force requirements for future operations."

Various specific examples of problems handled by operations research men in the Navy during the war are given in Admiral King's report. It should be emphasized that there were other types of wartime activity analogous to operations research but not carried out in theaters of operation. The work done by the Quality Control Sections of the Bureau of Ships and of the Bureau of Ordnance in the Navy and similar groups for the Ordnance Department and Signal Corps of the Army deserve particular mention. The work performed by these groups is essentially operations research applied to inspection, testing, preparation of specifications, and other problems of procurement of material. Peacetime successors of many of these groups are being continued.

8. **On the Development of Industrial Operations Research.**

Operations research activity evolved during World War II, because of the need for systematic analysis of performance of men, equipment, and tactics under the complexities of modern warfare. The fact that the value of this activity became so well recognized during the war and that peacetime successors are being continued in many parts of the Army and Navy indicates that we may expect to see analogous activity develop within industry in a few years. Thus, we can imagine an industrial operations research group attached to the "command" (i.e. management) of a corporation carrying out analyses of corporation operations analogous to those done by a military operations research group for its command. The domain of operation for such a group would consist of the various segments of the overall industrial process mentioned earlier. Statistical quality control work as it is commonly conceived at present would constitute industrial operations research over essentially one segment of the overall industrial process, namely inspection. Many opportunities exist for such groups in other major segments such as research development, consumer research, personnel selection, inventory control, and sales analysis.

When these industrial operations research groups come into exist-

ence, men with superior ability in various engineering and scientific fields will be required. These men must have the imagination and analytical skill to penetrate beyond the traditional mode of hunch analysis of situations. It will be found, just as in the case of military operations analysis, that the main tools which such men will use in their systematic analyses will be mathematical and statistical methods. Many of the problems which will be subjected to analysis will raise new mathematical and statistical problems which will in turn require careful theoretical investigation. But situations will be continually found in the various segments of the overall industrial process in which procedure, after periods of research, trial and error testing, will be simplified and standardized for routine applications. This process of theoretical study, trial and error testing, simplification, standardization, and finally widespread routine application is, indeed, the history of statistical quality control over a period of twenty years.

The problem of training personnel for industrial operations research is as broad and complicated as that of training research scientists and engineers in the various fields. Industry can only hope to take scientific and engineering personnel from that produced by the colleges and universities of the country. The problem of getting the basic mathematical and statistical training into the general scientific education of these men is one which the colleges and universities must solve. The situation relating to training in mathematics is quite satisfactory, but this, unfortunately, is not true for training in probability and statistics. The National Research Council Committee on Applied Mathematical Statistics is now preparing a report on the overall problem of statistical training. The situation at present is not a happy one. It will probably not be satisfactorily solved for years to come.

The usual situation in the past has been that universities can only give certain basic training for our future industrial operations research man and trust that when he gets into industry, he will have the required imagination, ingenuity, and basic skills to enable him to tackle successfully the problems which he will encounter. But with a greater degree of cooperation between universities and industry it should be possible to begin "indoctrinating" him while he is still a graduate student by making available problems of general interest and basic importance which arise in industry on which he could work. It would also be desirable for him to attend meetings or conferences where he can hear and participate in the discussion of problems of general interest. On the other hand such cooperation should be useful to industry by providing it with a slightly riper research man and also in providing opportunities for men already in industry to discuss the general and basic aspects of their problems with others outside their company and to get new ideas and fresh viewpoints.

This suggests that an effective way to promote cooperation between universities and industry in developing various phases of this industrial operations research activity would be to have meetings or seminars or conferences of relatively small groups of interested individuals from industry and from universities for the purpose of discussing problems, methods of research, and results of general interest to such groups. The burden of initiating discussion groups of this type at appropriate times falls primarily on universities and national scientific organizations, but the success of them will depend directly on the cooperation of industry.

It seems appropriate to conclude this discussion by quoting a few words from an address made by General H. H. Arnold last summer before a meeting of the Institute of Aeronautical Sciences, stating his views of the importance of operational research. His remarks are very pertinent from the point of view of training young men in this new type of activity, and they apply as well to industrial operations research as to military operations research:

> "Rare was the scientist whose interests led him to consideration of what I may call diffuse problems, connected with operational research. The number of scientists and techonologists who applied themselves to the solution of the difficul' problems associated with operations was pitifully small. I suspect this failure is a reflection upon our method of training. It seems to me we must do something to encourage greater interest in the application of the scientific method of reasoning to the evaluation of problems which deal not alone with machines, but with the integrated combination of men and machines."

Comments on Professor Wilk's Paper

WALTER A. SHEWHART

BELL TELEPHONE LABORATORIES

Professor Wilks has presented a most stimulating and challenging paper. In broad strokes, he surveys what the statistician has contributed in the application of statistics to inspection and production and also in the recent war. He makes it clear, however, that we have only scratched the surface in respect to the potential applications of statistics in industry. He pictures the future goal in which statistics is made to play an important role in the over-all industrial process including research, development, design, production, and inspection as well as sales and the analysis of consumer reaction. Management has been defined as the art and science of preparing, organizing, and directing human effort applied to control the forces and to utilize the materials of nature for the benefit of man. Wilks

implicitly points to the application of statistics in every portion of this broad field.

I know of no one better qualified than Wilks to set an attainable goal in the field of industrial statistics. As one who has made and is making important contributions to the theory of statistics, and as one who has been among the most active in directing and helping in the many fields of application, he knows whereof he speaks. He has told a little bit about the applications of statistics in the recent war; he was, however, too modest even to hint that he personally was one of the key figures in coordinating and directing these applications.

Not only has Wilks painted for us a future goal—he has given us a blueprint of some of the things that academic institutions, industrial organizations, and each one of us can and must do if we are to attain this goal. First he makes it clear that statistical training should be built into the training of all engineers similar to the way in which calculus and differential equations are now made a part of their training. Looking some distance into the future, it is the problem of the academic institutions to see that this training is provided in the engineering field. In the meantime, however, we need not sit and wait for the statistically trained engineers of the future to be turned out by the academic institutions. Many of us can, if we will, institute study groups within our own organizations, as is being done in many places in other fields. As another means of getting statistics across to those of us now in industry, Wilks suggests that industrial conferences be arranged along the lines of the one just given by the Newark College of Engineering. This calls for leadership on the part of the academic institutions, and also for the co-operation of industrial groups in making it possible for some of their men to attend.

Wilks gives us a short description of the important work done by statistical operational research groups in the recent war, and suggests some of the possibilities that we may hope to attain in our own industries if similar groups could be formed. He stresses the importance of the fact that the operational groups in the war were attached to "the command" and by implication indicates where similar groups in industry should report, namely, high enough in management that their work can be made effective. Finally, he suggests that in order to advance the operational approach in industry there should be conferences and seminars in which industry and academic institutions co-operate. He goes further by suggesting that perhaps the initial steps in this direction can best be taken by the academic institutions.

This paper is worthy of careful study, not only by engineers, but also by those who in academic institutions have charge of the training of future engineers, and by those in industry who have the managerial responsibility in the last analysis of determining to what extent applications of statistical theory will be made in their own industries.

Machine Accuracy Analysis

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Although the use of statistical quality control is usually thought of as a method of insuring good quality during the process of manufacture, there are several methods of insuring good quality at the beginning of manufacture.

We will consider one of these methods called "machine accuracy analysis." As its name implies, it is the analysis of several factors in a machine to determine its working accuracy. The method can be used with success on a number of different types of metal cutting machines, but is best applied to those machines which are automatic or semi-automatic, that is, where the operator can set the machine and merely load and unload. In this way we consider only the machine variables and not the operator. Where the operator is the deciding factor in the quality of each piece as in grinding, where the piece is sparked out, or in hand milling, where the rate of feed varies, the study should rightly be called "operation accuracy analysis."

The accuracy analysis for any operation applies only to the conditions and the particular machine on which the analysis is being made. A machine cutting soft brass with a form tool naturally is under less strain than if it were cutting stainless steel with a similar form tool. Also the same machine, because of newer bearings or a truer bed will work closer than the next one doing the same operation. It can be expected, also, that, all conditions being similar, the same machine will cut one kind of metal with one kind of tooling with the same accuracy next week as it did last week.

From the above it can be seen that a chart similar to Figure 1 can readily be made giving the accuracy of a number of different machines with certain standard tooling and cutting different metals. This chart gives only one figure of accuracy, but that figure is the result of several accuracy analyses which are combined to give the average machine accuracy for that particular tooling, material, and machine. Although the chart shown is used for Gridley multi-spindle automatics, other charts can be as easily made up for Brown & Sharp single spindle automatics, turret lathes, hand screws, grinders, millers, and so on.

A chart of this nature, in the hands of the planning depart-

FIGURE I: ACCURACY CHART FOR SIX-SPINDLE GRIDLEY AUTOMATICS

Machine Name and Invoice No.	Gross Slide Turning Tool				Cross Slide Form Tool				Roller Box Tool				Cross Slide Cut-off Tool			
	H.H. B	SAE X	SAE 5	SAE 3	H.H. B	SAE X	SAE 5	SAE 3	H.H. B	SAE X	SAE 5	SAE 3	H.H. B	SAE X	SAE 5	SAE 3
	R	1	2	3	R	1	2	3	R	1	2	3	R	1	2	3
	A	1	1	1	A	1	1	1	A	1	1	1	A	1	1	1
	S	1	0	2	S	1	0	2	S	1	0	2	S	1	0	2
	S	2	0		S	2	0		S	2	0		S	2	0	
⅞ Gridley No. 9344	30*	40	53	70	26	50	40	60	33	45	60	43	25	43	73	38
1" Gridley No. 124	36	39	43	90	40	70	70	90	37	40	65	60	35	63	70	58
⅞ Gridley No. 9552	40	47	60	75	32	55	54	63	41	40	40	45	32	42	71	35
1" Gridley No. 13208	36	45	66	75	25	17	55	50	20	42	55	53	30	47	55	40
1⅛ Gridley No. 11757	23	50	60	85	25	43	60	65	30	35	60	60	31	36	60	41
1⅜ Gridley No. 12617	20	40	55	80	32	38	57	65	25	46	55	55	25	38	58	52
1⅝ Gridley No. 12531	18	45	50	80	25	40	50	70	35	40	60	60	20	30	57	55

*Figures given are ten thousands of an inch. That is, the first figure in the first row, 30, is actually .0030", or thirty tenths.

ment, or process engineering, can prove invaluable in scheduling close tolerance work. Those machines which show on the chart to be capable of holding the closest tolerances are used for close tolerance finish work, and those not so good are used for roughing or primary operations. In this way each machine gives its most economical service, and the possibility of any machine producing defective work is reduced to a minimum.

The analysis of machine accuracy is a comparatively simple process and requires little computation; the hardest part is the collection of the necessary data. An analysis sheet similar to Figure 2 is used and all necessary work can be performed on this sheet. Procedure is as follows.

FIGURE 2. MACHINE ACCURACY ANALYSIS

MACHINE MAKE: 1" Gridley — MACHINE NO.: No. 124

SPEED, FEED, TYPE OF OPERATION: Turn O. D.

PART NAME: Stud — PART NO.: SD-5646 — DIM.: .6355-.6385

TOOLING: Cross Slide Turning Tool — MATERIAL: S. A. E. X 1112

OPERATOR: Jones — TAKEN BY. Eaton

1		2	3	4	5
X Dev. from Mean	DIM.	Frequency Tally	f Frequency	fX 1 x 3	f(X)² 1 x 4
15	.6385	I	1	15	225
10	80	IIII	4	40	400
5	75	IIIII IIIII IIIII	15	75	375
0	.6370	IIIII IIIII IIIII II	17	0	0
— 5	65	IIIII I	6	—30	150
—10	60	IIIII	5	—50	500
—15	.6355	II	2	—30	450
		TOTALS	50	20	2100

COMPUTATION

Sample size $n = 50$

Average Dimension $= .0001" \ (20/50) + .6370" = .63704"$

$\sigma_x^2 = [\Sigma f(X)^2 - (\Sigma fX)^2/n]/(n-1) = [2100 - 400/50]/49 = 42.7$

Dimension Standard Deviation $= .0001 \sqrt{42.7"} = .000654"$

Machine Operation Accuracy (OA) $= 6\sigma = .00392"$

Step No. 1

Fill in the heading of the analysis sheet. It is important that all portions of the heading be filled in correctly because, as noted above, the accuracy analysis applies only to those conditions noted in the heading.

Step No. 2

Take fifty consecutive pieces from the machine. Be sure that the machine is not readjusted and that there are no interruptions during the time taken to collect the fifty pieces.

Step No. 3

In the column headed "Dim." fill in the dimensions to be measured in the most convenient increments (.001", .0005", .0001") from maximum to minimum.

Step No. 4

Measure the individual pieces and make a tally mark in the column headed "tally" opposite the dimension measured. When the fifty pieces have been checked there should be some sort of a frequency distribution in this column.

Step No. 5

For convenience, call the dimension associated with the peak of the distribution the "mean" dimension (the true average dimension will be close to this figure), and in the column headed "Deviation From Mean" enter the figure zero (no deviation) opposite this value. Enter the deviation from the mean in whole numbers for each of the remaining cells. Although the actual deviation is in thou-

sandths, half-thousandths, or tenths, the whole numbers are used for ease in computation, the decimal being picked up later, as shown in the sample computation. Deviations below the mean will be negative.

Step No. 6
Total the tally marks in each cell and enter the totals in the column headed "Frequency" opposite each cell. Total these figures and enter them at the bottom of the column.

Step No. 7
Multiply the figures in column "f" by the figures in column "X" and enter the sums in the column headed "fX". Add these figures and enter the total at the bottom of the column.

Step No. 8
Multiply the figures in column "fX" by the figures in column "X" and enter the sums in the column headed "$f(X)^2$. Add these figures and enter the total at the bottom of the column.

Step No. 9
Complete the computation. The computation for the example is shown on the analysis sheet.

This particular example shows that the machine checked is not quite good enough to hold .003" tolerance on S.A.E.X1112 using a cross slide turning tool, and therefore any of this material scheduled for straight turning on this machine should not be held closer than .0045".

It should be pointed out that the procedure automatically shows not only whether or not the machine is producing within the blueprint tolerance but also whether or not the average is such that tool wear or other factors could push pieces outside the tolerance unexpectedly. After the accuracy analysis is taken it would be a simple matter to adjust the machine one way or the other so as to move the average into the correct position if necessary.

Acceptance Sampling Inspection by Variables

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The use of reject limits in connection with ordinary average and range charts is often suggested as a solution to the difficulties encountered in the acceptance sampling of small lots. (Reference 1 and 2). The procedure to be used in developing acceptance sampling plans for variables is not new (Reference 3 and 4) but is not as well known as the corresponding procedure for attribute inspection. Under some circumstances very small samples of measurements provide sharp discrimination between acceptable and non-acceptable lots.

The terms to be used are similar to those used in attribute inspection.

n = number of individual items in the sample.

σ = standard deviation of the lot (universe).

$\bar{X}$ = average of a sample.

μ = computed average of a particular lot.

μ_0 = desired (specified) value of lot average μ.

μ_1 = lower tolerance value for lot average.

μ_2 = upper tolerance value for lot average.

$\bar{X}_1$ = lower acceptance average for sample.

$\bar{X}_2$ = upper acceptance average for sample.

α = risk of rejecting lot if $\mu = \mu_0$.

β = riskof accepting lot if $\mu = \mu_1$ or if $\mu = \mu_2$.

$t(\alpha)$ = the value of t on a normal curve corresponding to a one tail area of α. Similarly for $t(\beta)$.

A few useful values of α and $t(\alpha)$ are given in the following table.

α	$t(\alpha)$
.10	1.282
.05	1.645
.025	1.960
.010	2.326
.005	2.576
.001	3.090

It is assumed that σ is known and that the distribution is approximately normal. The first assumption is extremely important, and a control chart should be kept on the standard deviation of all samples because lack of control of variability may invalidate the entire plan. The average need not be in control.

Single Tolerance Value of Sample Average.

The simplest type of problem encountered is that in which there is only one tolerance value of the average. An example sometimes encountered is tensile strength. We wish to accept material if the average tensile strength of the lot is 18,000 psi or greater ($\mu_0 = 18{,}000$) and to reject if the average tensile strength is 17,000 or less ($\mu_1 = 17{,}000$). From past experience we know that σ is 800 psi. What size sample should be tested, and how low a sample average should be accepted? For our risk of wrong decisions we choose α and β both equal to .05. Then $t(\alpha) = t(\beta) =$

1.645. For the particular case where α and β are equal the formulas for n and $\bar{X}_1$ are,

1) $n = [2t\sigma/(\mu_0 - \mu_1)]^2$

and

2) $\bar{X}_1 = (\mu_1 + \mu_0)/2$

Substituting in the formulas, we find $n = 6.9$ and $\bar{X}_1 = 17{,}500$. Since n must be an integer we choose 7 as the sample size, and our sampling plan is determined. Choose a sample of 7 items, test each, and compute the average. If the sample average is less than 17,500, reject the lot. Be sure to keep a control chart on the standard deviation. The idea of rejecting on a sample size of 7 may sound ridiculous, but this is a case of not liking the original requirements; it is not a fault of the plan itself.

If it were important to cut down the risks of wrong decisions we might choose α and β both equal to .01. Then both $t(\alpha)$ and $t(\beta)$ are equal to 2.326. Substituting in formulas (1) and (2), we find $n = 13.8$ and $\bar{X}_1 = 17{,}500$. A sample of 14 with an acceptance average of 17,500 meets the new requirements.

If it were important to insure the acceptance of standard material while considerable risk could be allowed for tolerance material, we might choose $\alpha = .01$ and $\beta = .10$. Then $t(\alpha) = 2.326$ and $t(\beta) = 1.282$. With different values of α and β the above formulas are incorrect, and the formulas needed are

3) $n = \sigma^2[t(\alpha) + t(\beta)]^2/(\mu_0 - \mu_1)^2$

and

4) $\bar{X}_1 = [t(\alpha)\mu_1 + t(\beta)\mu_0]/[t(\alpha) + t(\beta)]$

Substituting in these formulas we find $n = 8.3$ and $\bar{X}_1 = 17{,}356$. Theoretically our sample size should be 9, but we will use a sample size of 8 and note how this changes our risks of wrong decision.

Operating Characteristic Curve for Variables Plans

Each of the above acceptance sampling plans has an operating characteristic curve. To determine the O.C. curve we need to compute the probability that a lot of quality average μ will be accepted by the particular plan in use. The probability P(a) is computed in three steps:

Table I

μ	Plan	n = 7, $\bar{X}_1$ = 17,500 P(a)	n = 14, $\bar{X}_1$ = 17,500 P(a)	n = 8, $\bar{X}_1$ = 17,356 P(a)
18,200		.990	.999	.999
18,000		.951	989	.990
17,800		.840	.942	.919
17,600		.629	.805	.681
17,400		.371	.564	.319
17,200		.160	.290	.081
17,000		.049	.104	.010
16,800		.010	.024	.001

1) Compute $t = [(\bar{X}_1 - \mu)\sqrt{n}]/\sigma$.
2) For this value of t find p (one tail) from a table of the normal curve.
3) If $\bar{X}_1$ is greater than μ, then P(a) = p.
   If $\bar{X}_1$ is less than μ, then P(a) = 1 − p.

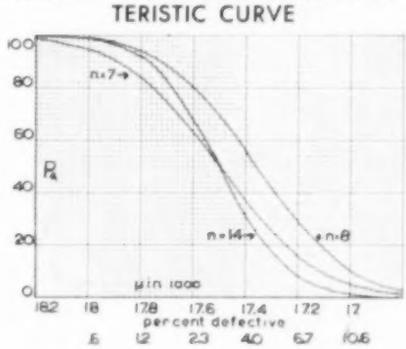
To find the probability that a lot with quality average $\mu = 17{,}700$ will be accepted on the first plan ($n = 7$, $\bar{X}_1 = 17{,}500$), we compute

1) $t = (17{,}700 - 17{,}500)\sqrt{7}/800 = .66$.
2) For $t = .66$ we find from the normal curve $p = .254$.
3) Since $\bar{X}_1 < \mu$, $P(a) = 1 - p = .746$.

Repeating the above calculations for different assumed values of μ we obtain Table 1 for each of the three plans.

Plotting the values of P(a) as ordinates against the values of μ as abscissas we obtain the O. C. curve of Figure 1. Theoretically these O. C. curves never attain a probability of 1.00. Actually the difference may be too small to show on a graph. The base scale has been reversed to have the curve look like the usual one for attribute sampling.

FIGURE 1: OPERATING CHARACTERISTIC CURVE



The use of n = 8 in the third plan has slightly increased the risks α and β. However, the change is less than would have occurred had n = 9 been used. Except for very small values of n the practical solution is to take the integer nearest the computed value of n as our sample size and to adjust α and β correspondingly.

If the single tolerance of the sample average were an upper instead of a lower one the same procedure would be followed with μ_1 replaced by μ_2, $\bar{X}_1$, by $\bar{X}_2$, and with these replacements the inequalities in the third step of computing the O. C. curve would be reversed.

Upper and Lower Tolerance Values of Sample Average

A simple solution for the case specifying both upper and lower tolerance values of the average can be given provided the tolerance averages $\bar{X}_1$ and $\bar{X}_2$ are equally spaced about the specified average, and provided the same risk β is used for lots of either tolerance average. Suppose that in the first example we wished to be protected from accepting lots if the average tensile strength were either 17,000 or less or 19,000 or more. Let both α and β be .05. Material of specified average quality may now be rejected on too high or too low a sample average. Thus we must split our risk α in two. Using $t(\alpha/2)$ to indicate the value of t on the normal curve corresponding to a one tail area of $\alpha/2$, we use the formulas

5) $n = \sigma^2[t(\alpha/2) + t(\beta)]^2/(\mu_0 - \mu_1)^2$

6) $\bar{X}_1 = [t(\alpha/2)\mu_1 + t(\beta)\mu_0]/[t(\alpha/2) + t(\beta)]$.

For our example $\alpha/2 = .025$, $t(\alpha/2) = 1.960$,

$\beta = .05$, $t(\beta) = 1.645$,
$\mu_0 = 18{,}000$, $\mu_1 = 17{,}000$.

Substituting these values in formulas (5) and (6), we find $n = 8.3$ and $\bar{X}_1 = 17{,}456$. Since $\bar{X}_2$ will be as much above μ_0 as $\bar{X}_1$ is below it, we find $\bar{X}_2 = 18{,}544$.

If we reduced our risks α and β to .01, we would obtain by the same procedure $n = 15$, $\bar{X}_1 = 17{,}475$, $\bar{X}_2 = 18{,}525$.

The computations to determine the O. C. curve are similar to those in the first example but are more involved since a lot having a quality average near the specified average may be rejected for either too high or too low a sample average. The steps in computation for a lot whose quality average μ is less than μ_0 are:

1) Compute $t_1 = [(\bar{X}_1 - \mu)\sqrt{n}]/\sigma$ and $t_2 = [(\bar{X}_2 - \mu)\sqrt{n}]/\sigma$.
2) For each value of t find the corresponding p (one tail) from a table of the normal curve.
3) If $\bar{X}_1 > \mu$, $P(a) = p_1 + p_2$.
   If $\bar{X}_2 < \mu$, $P(a) = 1 - p_1 - p_2$.

Using $\bar{X}_1 = 17{,}456$, $\bar{X}_2 = 18{,}544$, $\mu_0 = 18{,}000$, $n = 8$, $\sigma = 800$, and following this procedure we obtain Table 2.

Since the probability of accepting a lot whose quality average is 18,400 is the same as for a lot of quality average 17,600, we need to work with only one side of the specified average. The O. C. curve for both of the sampling plans developed is shown in Figure 2.

FIGURE 2: OPERATING CHARACTERISTIC CURVES, TWO SIDED PLAN

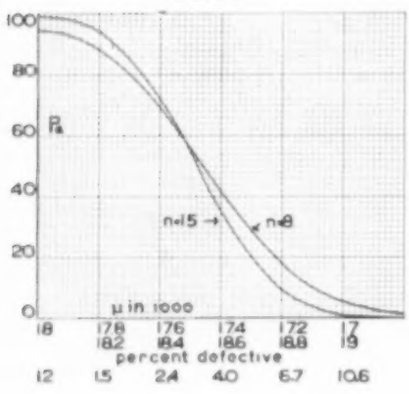


Table 2

μ	t_1	t_2	p_1	p_2	P(a)
18,000	1.93	1.93	.027	.027	.946
17,800	1.22	2.63	.111	.004	.885
17,600	.51	3.32	.305	.000	.695
17,400	.20		.421		.421
17,200	.91		.183		.183
17,000	1.61		.054		.054
16,800	2.31		.010		.010

Relation Between Lot Average and Per Cent Defective

Frequently the tolerance values of the average are set in terms of the per cent of individual items above or below a specification limit. Whether or not an individual specification limit on psi has any meaning may be debatable. Rather than change the data we will assume that the lower specification limit L for individual pieces is 16,000 psi. Assuming a normal distribution (which needs considerable justification) we can compute for any assumed μ the per cent of individual items outside specification limit. To do so we

1) compute $t = (\mu - L)/\sigma$;
2) find p (one tail) for this value of t from a normal curve.

The per cent defective is then 100p.

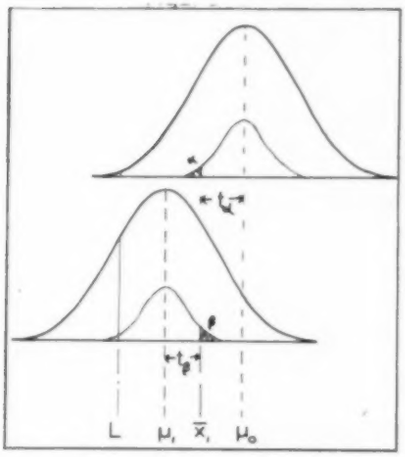
If there are two specification limits equally spaced about the specified average, the procedure is essentially the same, the numerator $(\mu - L)$ being the distance to the nearest specification limit. This procedure assumes that the distance between specification limits is at least 6σ, so that lots will have defectives either below the lower specification limit or above the upper specification limit, but not both. In the present case, if our specification limits for individuals were 16,000 to 20,000, the difference would be only 5σ, so that lots of quality average near 18,000 would have defectives both above specification and below specification. Following this procedure and taking into account both classes of defectives, the per cents defective corresponding to the lot average were computed. These are shown in Figure 2.

It now appears that a variables sampling plan can, with certain important assumptions, be specified by an n and an $\bar{X}_1$, or by an n and an $\bar{X}_1$ and an $\bar{X}_2$. We might suspect that there are as many varieties of variables sampling plans as there are attribute sampling plans. As a matter of fact there are a great many more possible. Romig (Reference 3) has formulated a great variety of plans, some of which minimize the total inspection assuming detailing of remainders, others that combine a given AOQL with fixed producer's and consumer's risks. Some unpublished work has combined variables acceptance inspection with attribute inspection, the severity of the attribute sampling plan being based on the result of the variables inspection. The possible applications of variables acceptance sampling are legion, especially when we consider the need for small samples in some problems, and the fact that frequently variables data are arbitrarily classified by attributes. Measuring a part and then classifying it as merely good or bad can be justified only when unit inspection costs are very low. Despite the computational difficulties involved, the savings may be great, and it is quite possible that the variables acceptance sampling plans of the future will be as useful as the various attribute sampling plans are now.

Derivation of Formulas

The formulas depend on nothing more than the standard error of the mean of a sample of size n. Figure 3 represents a lot of quality average μ_0 and a second lot of quality average μ_1. The smaller curves represent the distribution of averages of samples of size n.

FIGURE 3: FREQUENCY DISTRIBUTION AND POSITIONS OF AVERAGES



Since the standard deviation of the average of a sample of size n is $\sigma/\sqrt{n}$, the t units must be multiplied by $\sqrt{n}/\sigma$ to obtain scale units of psi. Thus

$$\mu_0 - \bar{X}_1 = t(\alpha)\sigma/\sqrt{n},$$
$$\bar{X}_1 - \mu_1 = t(\beta)\sigma/\sqrt{n}.$$

Adding these equations we obtain

$$\mu_0 - \mu_1 = [t(\alpha) + t(\beta)]\sigma/\sqrt{n},$$

which when solved for n gives formula 3.

Dividing the equations we get

$$(\mu_0 - \bar{X}_1)/(\bar{X}_1 - \mu_1) = t(\alpha)/t(\beta),$$

which when solved for $\bar{X}_1$ gives formula 4.

The fraction of the larger curves below the specification limit L represents the per cent defective for lots of quality average μ_0 and μ_1 respectively.

References

1) A. J. Winterhalter; Development of Reject Limits for Measurement; Industrial Quality Control, Jan., 1945, March, 1945.
2) Norbert L. Enrick; Operating Characteristics of Reject Limits for Measurement; Industrial Quality Control, September, 1945.
3) Harry G. Romig, Allowable Average in Sampling Inspection; Columbia University, 1939.
4) Paul Peach; An Introduction to Industrial Statistics and Quality Control, (revised edition); Edwards and Broughton, 1947.

Saving Time in Testing Life

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There are two basic methods of controlling quality. The first method is the condemning or screening of lots because they contain too many defective units. The second method is the keeping of the process so tuned, with its resulting low percentage of defective units, that no condemning or screening is necessary. The second method is the one which is true economic control of quality.

One of the conventional methods of keeping a process tuned is to set limits statistically for the average and range of the measurements on periodically drawn samples, and to use as a criterion for corrective action any average or range that falls outside the limits. The data must be obtained quickly and immediate action taken where indicated to eliminate causes of variation while they still exist and before many defective units have been made. In testing life, however, use of the statistics of average and range requires that each test be continued until the last unit has reached the end of its life. The consequent delay in obtaining the data is fatal to the effective use of this Modern Quality Control Technique.

In many cases, the difficulty has been partially overcome by increasing the severity of the life test. A classic example is the shortening of the life of incandescent lamps from 1000 hours to about 5 hours by burning at 150% of rated voltage. Even at this acceleration, however, it often requires 7 or 8 hours to burn out the last lamp of a sample; yet the final result might yield an average so low or a range so great that need of corrective action is indicated. Attempts to shorten the life further cause abnormal arcs and do not give a true picture of normal life. Since the test cannot be further accelerated, it is necessary to accelerate the statistics.

In conventional statistics, average is used to indicate a shift in the whole population; range is used to indicate a change in population dispersion. A shift in the whole population can also be indicated by the median, or central failure in the sample; a population shift or change in dispersion can

be indicated by the minimum, or first failure in the sample. The use of median and minimum as statistics substantially accelerates the results. A tendency toward short life which is indicated by the sample is indicated quickly. It is not necessary to continue the test beyond the median, and corrective action can be started promptly.

Before adopting the statistics of median and minimum, three questions must be answered. First, does median give the desired picture of life? Second, how can control limits for medians be established? Third, how can control limits for minima be established?

1. Does median give the desired picture of life?

In the case of incandescent lamp life test, a large amount of past data for various types was studied. Table I is a typical set of data accumulated before control was established. In the long run, the average of the medians (1435) practically coincides with the average of the averages (1433). This is to be expected in an inherently normal distribution. Furthermore, the differences between median and average in individual samples are insignificant.[1] For incandescent lamps then, median does give the desired picture of life. An analysis along these lines is recommended whenever median is being considered for adoption as a statistic.

2. How can control limits for medians be established?

Control limits for averages are[2]

$$\text{UCL (av)} = \bar{\bar{X}} + A_2\bar{R} \quad \text{.....(1)}$$

$$\text{CL (av)} = \bar{\bar{X}} \quad \text{.....(2)}$$

$$\text{LCL(av)} = \bar{\bar{X}} - A_2\bar{R} \quad \text{.....(3)}$$

In equations (1) and (3), the term $A_2\bar{R}$ is three standard deviations of averages. The relation between standard deviation of medians and standard deviation of averages is given by [3]

$$\sigma_{\tilde{x}} = \sqrt{\pi/2}\,\sigma_{\bar{x}} \quad \text{.....(4)}$$

(This and subsequent notation is explained at the end of the article.) Thus control limits for medians become:

$$\text{UCL(me)} = \bar{\bar{X}} + \sqrt{\pi/2}\,A_2\bar{R} \quad \text{.....(5)}$$

$$\text{CL(me)} = \bar{\bar{X}} \quad \text{.....(6)}$$

$$\text{LCL(me)} = \bar{\bar{X}} - \sqrt{\pi/2}\,A_2\bar{R} \quad \text{.....(7)}$$

The statistics do not, however, give $\bar{R}$ directly. But Table I shows that the average of the medians (1435) is half way between the average of the minima (1184) and average of the maxima (1686). This is to be expected in an inherently normal distribution. Therefore:

$$\bar{R} = 2\,(\bar{\bar{X}} - \bar{\bar{x}}) \quad \text{.....(8)}$$

Substitute the value of $\bar{R}$ from (8) in (5) and (7) and regroup:

$$\text{UCL(me)} = (A_2\sqrt{2\pi} + 1)\,\bar{\bar{X}} - A_2\sqrt{2\pi}\,\bar{\bar{x}} \quad \text{.....(9)}$$

$$\text{LCL(me)} = A_2\sqrt{2\pi}\,\bar{\bar{x}} - (A_2\sqrt{2\pi} - 1)\,\bar{\bar{X}} \quad \text{.....(10)}$$

TABLE I

Typical Data For Life Of Incandescent Lamps In Hours Before Establishment of Control

(Each sample contains 5 lamps)

Sample No.	Minimum	Maximum	Range	Median	Average	Differ'ce Betw'n Median and Aver'e
1	850	1270	420	1100	1080	20
2	900	1570	670	1280	1390	110
3	1370	1550	180	1460	1460	0
4	1080	1400	320	1350	1380	30
5	1060	1130	70	1060	1090	30
6	860	1550	690	1250	1230	20
7	1060	2010	950	1440	1370	70
8	1040	1420	380	1230	1310	80
9	1090	2170	1080	1630	1630	0
10	1930	2280	350	2100	2120	20
11	810	1390	580	1210	1230	20
12	1480	2160	680	1760	1600	160
13	2120	2590	470	2410	2290	120
14	1990	2260	270	2080	2050	30
15	1470	1640	170	1500	1580	80
16	1280	1950	670	1550	1510	40
17	1010	1430	420	1210	1270	60
18	1240	1710	470	1620	1580	40
19	1450	2100	650	1560	1560	0
20	340	920	580	730	750	20
21	470	1360	890	1260	1200	60
22	1490	1850	360	1560	1680	120
23	1670	1860	190	1770	1730	40
24	1080	1390	310	1160	1170	10
25	920	1680	760	1300	1260	40
26	1160	1500	340	1500	1420	80
27	1180	1340	160	1270	1290	20
28	1290	1650	360	1560	1560	0
29	1000	1940	940	1150	1210	60
30	1660	2200	540	1940	1940	0
31	430	1100	670	840	760	80
32	1110	1590	480	1140	1150	10
Averages	1184	1686	503	1435	1433	46

1. Average of the ranges is 503 hours. From this, the standard deviation of units is about 216; standard deviation of averages about 97. The average of the differences (46) is therefore, less than half of one standard deviation of averages; the greatest difference (160 in sample 12) is only 1.65 standard deviations of averages.

2. American War Standards Z1.1, Z1.2—1941 American Standards Association

3. M. G. Kendall, "Advanced Theory of Statistics," Charles Griffin & Co., London, 1943, p. 213.

To simplify these expressions set

$A_2\sqrt{2\pi}+1=M_1$ .....(11)

$A_2\sqrt{2\pi}=M_2$ .....(12)

$A_2\sqrt{2\pi}-1=M_3$ .....(13)

Equations (9) and (10) then become:

$UCL\ (me)=M_1\,\bar{\bar{X}}-M_2\,\bar{\bar{x}}$ .....(14)

$LCL\ (me)=M_2\,\bar{\bar{x}}-M_3\,\bar{\bar{X}}$ .....(15)

Values of M_1, M_2, and M_3 for various values of sample size (n) are listed in Table III.

Example:

From the data in Table I:

$\bar{\bar{X}}=1435$

$\bar{\bar{x}}=1184$

$n=5$

From Table III ($n=5$):

$M_1=2.44$

$M_2=1.44$

$M_3=.44$

The control limits are:

$UCL(me)=(2.44)\ (1435)-(1.44)\ (1184)=1790$

$CL(me)=1435$

$LCL(me)=(1.44)\ (1184)-(.44)\ (1435)=1080$

3. How can control limits for minima be established?

The method is basically similar to that used in establishing conventional limits. Conventional limits allow for the variations in the statistics which are of no significance. These insignificant variations are due to the constant system of chance causes in the process and operation of chance in sample selection. Each limit is placed at a point beyond which it is very improbable (probability .0015) that chance can be operating alone. A statistic beyond the limit is then considered conclusive evidence that some other dominant cause is affecting the process.

Similarly the upper limit for minima is so placed that the probability is .0015 that chance alone can cause the minimum to exceed it. Stated differently, the probability that all units in the sample will exceed the limit is .0015. Since the sample contains n units, the probability that any one unit will exceed the limit is $\sqrt[n]{.0015}$ [4]

To evaluate the points for given probabilities, the population center and the standard deviation of its units must be known, and its inherent approach to normal distribution must be estimated. The statistic of average median locates the population center. From the two statistics of average median and average minimum, the standard deviation of units can be calculated by [5]

$\sigma_x'=\bar{R}/d_2=2\ (\bar{\bar{X}}-\bar{\bar{x}})/d_2$

The inherent frequency distribution of incandescent lamp life can be assumed to be substantially normal.[6]

The limit for each of the unit probabilities represented by $\sqrt[n]{.0015}$, for various values of n, is then uniquely determined. These limits have been calculated in terms of standard deviations of units above the population center.

Thus the limit can be written:

$UCL(min)=\bar{\bar{X}}+N_1\sigma_x'$

N_1 is number of standard deviations of units above the population center for a unit probability of $\sqrt[n]{.0015}$.

Values of $\sqrt[n]{.0015}$ and N_1, for various values of n, are listed in Table II.

Similarly the lower limit for minima is so placed that the probability is .0015 that chance alone can cause a sample to contain a unit below it. But each sample contains n units. Therefore, the limit is so placed that the probability of a unit falling below it is .0015/n [7]

4. The probability of the simultaneous occurence of a number of events is the product of the separate probabilities.

5. American War Standards Z1.1, Z1.2—1941 American Standards Association

6. One basis for this assumption is the coincidence of average and median. Another is the location of both of these statistics half way between minimum and maximum.

7. If the probability of a unit is .0015/n, the probability that a sample of size n will contain such a unit is n x .0015/n = .0015.

TABLE II

Values of N_1 and N_2 For Various Sample Sizes [8]

Sample Size (n)	$\sqrt[n]{.0015}$	N_1	$\frac{.0015}{n}$	N_2
3	.114	1.21	.00050	3.29
4	.197	.85	.00038	3.36
5	.272	.61	.00030	3.42
6	.338	.42	.00025	3.48
7	.395	.27	.00021	3.52
8	.444	.14	.00019	3.54
9	.486	.03	.00017	3.59

(8) N_1 is the number of standard deviations of units above the population center for a unit probability of $\sqrt[n]{.0015}$.
N_2 is the number of standard deviations of units below the population center for a unit probability of .0015/n.

The limit for each of the unit probabilities represented by .0015/n, for various values of n, is uniquely determined. These limits have been calculated in terms of standard deviations of units below the population center. Thus the limit can be written:

$LCL\ (min)=\bar{\bar{X}}-N_2\sigma_x'$ .....(18)

N_2 is number of standard deviations of units below the population center for a unit probability of .0015/n

Values of .0015/n and N_2, for various values of n, are listed in Table II.

Substitute in (17) and (18) the value of σ_x' from (16) and regroup:

$UCL\ (min)=(2N_1/d_2+1)\bar{\bar{X}}-(2N_1/d_2)\bar{\bar{x}}$ .....(19)

TABLE III

Factors For Computing Control Limits For Medians and Minima

For substitution in:
$UCL\ (me)=M_1\bar{\bar{X}}-M_2\bar{\bar{x}}$
$LCL\ (me)=M_2\bar{\bar{x}}-M_3\bar{\bar{X}}$
$UCL\ (min)=M_4\bar{\bar{X}}-M_5\bar{\bar{x}}$
$LCL\ (min)=M_6\bar{\bar{x}}-M_7\bar{\bar{X}}$

Sample Size[9] (n)	M_1	M_2	M_3	M_4	M_5	M_6	M_7
3	3.56	2.56	1.56	2.43	1.43	3.90	2.90
4	2.82	1.82	0.82	1.82	0.82	3.26	2.26
5	2.44	1.44	0.44	1.52	0.52	2.94	1.94
6	2.21	1.21	0.21	1.33	0.33	2.74	1.74
7	2.05	1.05	0.05	1.20	0.20	2.61	1.61
8	1.93	0.93	−0.07	1.10	0.10	2.48	1.48
9	1.84	0.84	−0.16	1.02	0.02	2.42	1.42

(9) If the sample size is an even number, median is half way between the two central values.

$$LCL\ (min) = 2N_2/d_2\bar{\bar{x}} - (2N_2/d_2 - 1)\bar{\bar{X}} \quad \text{.....(20)}$$

To simplify these expressions set

$$2N_1/d_2 + 1 = M_4 \quad \text{.....(21)}$$
$$2N_1/d_2 = M_5 \quad \text{.....(22)}$$
$$2N_2/d_2 = M_6 \quad \text{.....(23)}$$
$$2N_2/d_2 - 1 = M_7 \quad \text{.....(24)}$$

Equations (19) and (20) then become

$$UCL(min) = M_4\bar{\bar{X}} - M_5\bar{\bar{x}} \quad \text{.....(25)}$$
$$LCL(min) = M_6\bar{\bar{x}} - M_7\bar{\bar{X}} \quad \text{.....(26)}$$
$$\text{and of course } CL(min) = \bar{\bar{x}} \quad \text{.....(27)}$$

Values of M_4, M_5, M_6, and M_7, for various values of n, are listed in Table III.

Example:

From the data in Table I: $\bar{\bar{X}} = 1435$

$\bar{\bar{x}} = 1184$

$n = 5$

From Table III (for $n = 5$):

$M_4 = 1.52$

$M_5 = 0.52$

$M_6 = 2.94$

$M_7 = 1.94$

The control limits are:

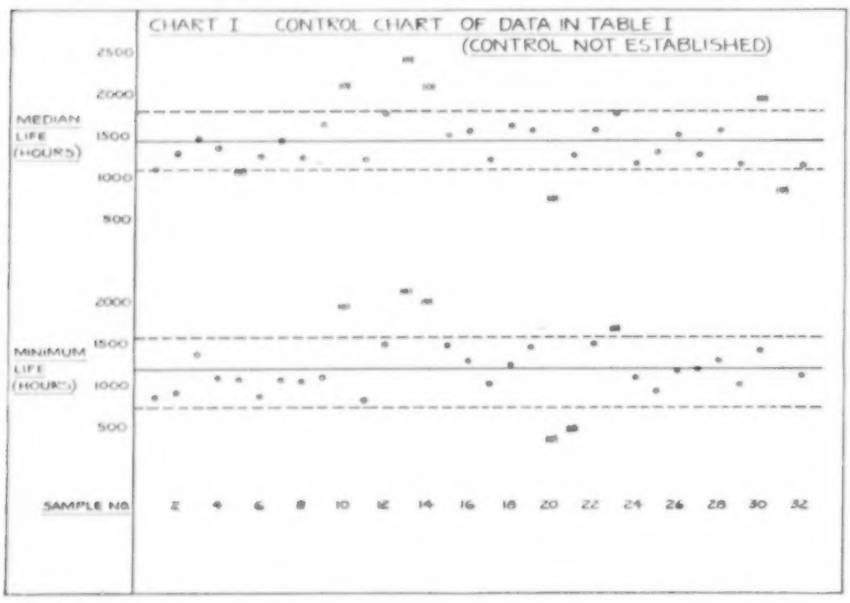
$UCL\ (min) = (1.52)(1435) - (0.52)(1184) = 1565$

$CL\ (min) = 1184$

$LCL\ (min) = (2.94)(1184) - (1.94)(1435) = 720$

One advantage of these statistics is the saving in time and facilities required for test. A second advantage is the elimination of the calculation of averages and ranges. There is one disadvantage. For the same sample size, median is about 25% less stable, and therefore as a control statistic less sensitive, than the average.

The great advantage is not only that the corrective action is fast; but also that the fastest action is taken when most needed; i.e., when life is short. Chart I (control chart of the data in Table I) illustrates this especially for samples 20, 21 and 31. Action on these statistics was possible in the accelerated equivalent of 340, 470 and 430 hours (i.e., about 2 hours). Action based on conventional statistics would have been deferred until the accelerated equivalent (about 5½ hours) of 920, 1360 and 1100 hours, respectively.



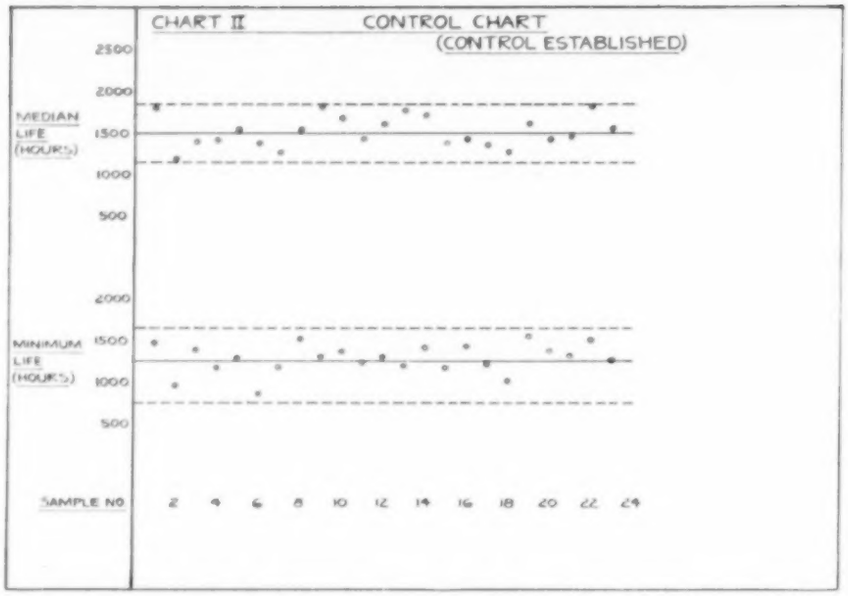


Chart II illustrates the appearance of charts based on these statistics after control has been established. The improvement in life uniformity due to the fast corrective action has been extremely gratifying.

DEFINITION OF SYMBOLS

$\bar{\bar{X}}$: average of averages

$\bar{R}$: average of ranges

$\bar{\bar{X}}$: average of medians

$\bar{\bar{x}}$: average of minima

$\sigma_{\bar{x}}$: standard deviation of averages

$\sigma_{\tilde{x}}$: standard deviation of medians

σ'_x: standard deviation of units

A_2: factor which depends on sample size

d_2: factor which depends on sample size

UCL (av): upper control limit for averages

CL (av): central line for averages

LCL (av): lower control limit for averages

UCL (me): upper control limit for medians

CL (me) central line for medians

LCL (me): lower control limit for medians

UCL (min): upper control limit for minima

CL (min): central line for minima

LCL (min): lower control limit for minima

N_1, N_2, M_1, M_2, M_3, M_4, M_5, M_6 and M_7 are used merely to replace cumbersome expressions and to simplify.

Third Annual Rochester Clinic

The Rochester Section of the American Society for Quality Control, in affiliation with the Industrial Management Council of Rochester, held their annual Clinic on Tuesday, February 18th, at the Rochester Chamber of Commerce.

Eleven clinics, luncheon and dinner meetings, and eighteen gage exhibitors, drew a record registration of over seven hundred members and guests from the Western New York area, making this by far the most successful clinic ever to be sponsored by the Rochester group.

Lewis B. Swift, President of The Taylor Instrument Companies, Rochester, New York, and Chairman of the Industrial Management Council, spoke at the noon luncheon meeting. His topic, **"Management Views Quality Control"** was a tribute to the industrial accomplishments of the war years, 1940-45, and the important contribution of quality control methods used widely for the first time as a management tool or technique to assure greater precision with greater production than ever attained heretofore. World War II was an opportunity to test our industrial progress, a sort of final examination that had to be passed at a high level. Management is deeply interested in new methods which will improve operations and help control our present complex industrial machine.

Mr. J. M. Juran, Chairman, Department of Administrative Engineering, New York University, was the speaker at the evening dinner meeting. In Mr. Juran's address **"Whose Job to Control Quality?"**, the organizational problems which often involve those persons using quality control methods were presented and discussed with thoroughness and authority.

Those people to whom responsibility for the quality function is assigned must have recognition and a place in the organization. This does not mean that a whole new department with a vice-president in charge of quality at its head is to be created as so many newcomers suddenly finding this tool in their hands would have it. Quality control, like any other management tool, must prove its worth and sell itself to management. It is better to begin operations slowly in an established trunk of the organization and thereby minimize jurisdictional disputes. In his experience, Mr. Juran has found that a new department in an organization must spend months, even years, acquiring jurisdictional rights before it can function properly. It is better for a quality control group to show results first, then the proper place in the organization will be made available.

CLINIC SUMMARIES

1. **"Sub-dividing Dimensions for Quality Control Purposes."**—C. W. Kennedy, Quality Control Engineer, Federal Products Corporation, Providence, R. I.

   Mr. Kennedy stressed the importance of having the right gage for the job in order to control quality most efficiently during production. His talk was amply illustrated with the latest gages which he used to present up-to-the-minute developments and techniques in gaging practice and to show their use for acquiring effectively data for control charts.

2. **"Selection of Personnel for the Quality Control Organization"** —W. R. Purcell, Manager, Quality Control, Lamp Division, Sylvania Products, Inc., Salem, Mass.

   In this clinic, Mr. Purcell offered a thoughtful appraisal of the qualifications desirable in the personnel who must handle the quality control problems in industry today. The installation of these new techniques require that the "know how" of the manufacturing processes and inspection procedures be combined with the "know how" of the modern quality control techniques. If, therefore, an organization has no staff Quality Control Department, it is necessary for the line quality control personnel to have the rare combination of both types of "know how." If, on the other hand, the organization has a staff Quality Control Department, the personnel of such a department can concentrate on the "know how" of the modern technique and cooperate with the line quality control personnel which has the manufacturing and inspection "know how."

3. **"Sequential Analysis for Measurement"**—Irving W. Burr, Professor of Mathematics, Purdue University.

   Sequential analysis, a wartime development, has in the past two years become a widely used sampling plan, notably in the receiving inspection area. Mr. Burr presented new applications of this plan for evaluating variable measurements in cases other than receiving inspection.

4. **"Analysis of Variance in the Chemical Laboratory"**—Roland Noel, Director of Control, Bristol Laboratories, Syracuse, New York.

   Mr. Noel presented examples of the use of analysis of variance to study the precision and accuracy of chemical test procedures. The role of statistical techniques in solving a problem which increased tremendously the production of penicillin was an example of outstanding interest to the group.

5. **"Cooperation Between Production and Inspection Department for Success"** — C. J. Hudson, Quality Manager, Norton Company, Worcester, Mass.

   This clinic stressed the vital importance of teamwork and cooperation necessary between the inspection and production groups. This is achieved by an understanding of the quality control methods by both operators and supervision in the production group as well as in the inspection group. Training courses for operators and supervision are essential to this end.

6. **"Sampling Procedures for Products Acceptance"**—Arthur Wilder, Quality Control Engineer, General Electric Company, Providence, R. I.

Manufacturers engaged in the production of parts which can be classified as accepted or rejected are overlooking a money-saving tool if they are not using the principle of sampling for product acceptance. Sampling on a statistical basis gives most information per inspection dollar with a known degree of accuracy.

It is important to know when to adopt sampling inspection, how to set it up, and how to handle the accompanying limitations.

7. **"Is Your Inspection Department Inspecting?"**—Edwin A. Boyan, Assistant Professor of Business Management, M.I.T., Cambridge, Mass.

Mr. Boyan ably appraised the functions of quality control supervision and suggested methods of making quality control a successful enterprise. Quality originates at the machine or process which does the work and, therefore, whether the work is done well or poorly becomes the prime responsibility of the production operators and their supervisors. The operator must be taught to check his own work and not to rely on a periodic inspection or subsequent sorting operation to find his mistakes.

To the inspection group should go the responsibility of seeing that production maintains quality by providing gages, instructing in their use, acting to correct trouble, making recommendations to improve tooling or design, seeing that tool and design changes are made, and keeping changes out of the factory that are neither approved or proved.

Money must be spent to obtain and improve quality and inspector rates must be equal to or better than operator rates to assure respect for the inspection function.

8. **"Practical Use of Histogram in Analyzing Process Quality"**—M. D. Benedict, New England Regional Chairman of American Society for Quality Control, Gillette Safety Razor Co., Boston, Mass.

Mr. Benedict brought out in this discussion that in many instances the use of the basic frequency distribution curve will often yield more prompt and intelligent information than the control chart, and yet in the elementary quality control courses, this normal probability curve is all too often passed over as an interesting phenomenon.

There is a need in industry for more basic information as to the ability of machines and processes to meet specifications. The use of "Operation Accuracy" studies through the medium of histograms can, in a large measure, meet these requirements. Such studies provide a firm foundation for sound engineering and factory planning and permanent, economical, practical specifications. A knowledge of the behavior of frequency diagrams and of the manner in which they combine will help in setting tolerances and manufacturing techniques to result in an overall high quality product.

9. **"Product and Process Control in the Chemical Industry"**—M. D. Gross, Research Chemist, University of Akron, Akron, Ohio.

The advantages of applying statistical methods to the control of industrial chemical processes were outlined in this clinic. Statistical methods furnish a quantitative and scientific basis for judgment in the establishing of specifications and in determining whether or not a process is running within these specifications. While statistical methods can locate the source of variation in a process that is out of control, it must be remembered these methods in themselves do not remedy the trouble. It is possible to eliminate considerable laboratory testing if statistical methods are used to extract the maximum amount of information from the test data.

10. **"Demonstration, Construction, and Application of Average and Range Charts"**—C. C. Craig, Professor of Mathematics, University of Michigan, Ann Arbor, Mich.

Mr. Craig presented information designed to simplify the use of $\bar{X}$ and R charts which are so widely used in quality control work.

11. **"How to Interest Production Supervision and Operators in Quality Control"** — E. L. Fay, Chief Inspector, John Deere Tractor Company, Waterloo, Iowa.

The first and most important step in the introduction of quality control to supervision and production operators is to establish definite results in a relatively small, even obscure, undertaking. In this way, supervision can be brought to believe that they have actually discovered a new tool which will work to their advantage. An improper approach more often than not creates a feeling of resentment at this encroachment in their work designed to expose their mistakes by underhanded methods. Obtain cooperation first then follow through and produce results. This small start is a good sound wedge to open the doors for expansion of the quality control program.

PURDUE UNIVERSITY COURSE

An eight-day course in Statistical Quality Control will be offered by Purdue University June 27 thru July 5, 1947. This course is intended to meet the needs for additional training of men and women who have had some previous instruction or practical experience in the subject.

Topics to be offered are: the background of control charts, significance of differences, analysis of variance, linear and multiple correlation, sequential analysis and other sampling, use of calculating machines. Prerequisites are the first course or its equivalent. The emphasis is on applications. All techniques are to be explained as simply as possible.

The instructors in the course will be: Professors Irving W. Burr, Purdue University; Mason E. Wescott, Northwestern University; Lloyd A. Knowler, Iowa State University; and Edwin G. Olds, Carnegie Institute of Technology.

The tuition is $100, and additional information can be obtained from Professor Burr.

Reviews

GRANT, EUGENE L., "Statistical Quality Control," McGraw-Hill Book Co., New York and London, 1946, 563 pp.
Review by H. F. Dodge, Bell Telephone Laboratories.

This book gives an excellent presentation of those simple but powerful statistical techniques that can be widely used in industry, more particularly in production and inspection operations, to control the quality of manufactured products, and to reduce costs.

Explaining that the book is a working manual, the author describes the general purpose of the book in the following words:

> "The most effective use of these (statistical) techniques depends upon their being understood by production and inspection supervisors, by engineers, and by management. The object has been to write a book that might be immediately useful to all of these groups. No attempt has been made to write for the professional statistician or the mathematician. The aim has been to give just enough theory to supply practical working rules that will enable one to recognize the limitations of the methods as well as their many uses."

The author has attained this objective, writing with a clarity that should take much of the mystery out of the specialized language of the statistician.

In outline the book comprises five parts:

1. What statistical quality control will do;
2. The Shewhart control chart for variables;
3. Other Shewhart control charts;
4. Statistical approach to acceptance procedures;
5. Making statistical quality control work.

Profiting from the trend of things during the war, the author has concentrated his attention on the simpler tools of statistics that have been found most readily applicable on a wide scale with a minimum of special training. For production operations, the primary emphasis is on techniques associated with the various Shewhart control charts for controlling quality in process; and, for inspection operations, the emphasis is on acceptance sampling procedures. There has been no attempt to cover statistical methods that involve a higher level of mathematical treatment such as tests of significance, analysis of variance, correlation, and regression. These topics, one reads, have a greater place in research and development.

The author has brought together under one cover and, in the opinion of the reviewer, skillfully coordinated much of the wartime training material in quality control methods, interweaving the results of his own wide experience in this field as a consultant to industry and as a teacher. The presentation of the control chart techniques, for example, follows closely the tenor and terminology of the A.S.A. War Standards on quality control, notably Z1.3 "Control Chart Method of Controlling Quality During Production," which were promulgated by the War Department to stimulate the varied uses here covered in satisfying detail, and which were used as texts in country-wide intensive training courses. Control charts in their various forms are, in fact, given first place in prominence, both with respect to space allotted and emphasis. As the author points out and demonstrates, the core of the problem of controlling quality is the continuing active study of observable variations in product characteristics right down in the center of things in the manufacturing process. With this in mind, he refers to the control chart as the most powerful statistical tool for determining just what is going on and for deciding when a production process is being disturbed by causes of variation that are worthwhile identifying and eliminating.

The subject of acceptance sampling is treated at some length with particular reference to and explanation of (1) the Dodge-Romig sampling tables as applied to receiving, process, and final inspections in a manufacturing plant, and (2) the standard inspection procedures which were developed and widely used during the war by the Army Service Forces, particularly the Ordnance Department, in connection with acceptance inspections of war materiel. With respect to the latter, the material presented is consistent with that used in quality control training programs for Army key inspection personnel. Sequential sampling is touched on briefly, but reference is made to other sources for its application.

Sufficient material on fundamental statistical concepts and probability is included to provide an adequate working knowledge of the underlying principles of the statistical techniques presented in the book. Attention is given to the part that can be played by these techniques in establishing and appraising tolerances. Finally, consideration is given to the general subject of organizing for statistical quality control with recommendations regarding the place that it should take in manufacturing and inspection operations.

In his handling of the technical material on these subjects, the author appears to hold constantly in mind that the reader wants to know why these methods work, how to interpret their results, and how to decide which method to use in any particular case. Certain chapters are earmarked for the special attention of those at the management level.

One of the outstanding features of the book is its treatment of many excellent examples, a total of 45. This is done realistically and in a way that will appeal to the practical man. The facts of the case are given, then follows the detailed method of approach, results obtained, the action taken, and a

thorough discussion of the particular contributions of statistical approach. Moreover, the examples quite generally represent actual problems, not made-up ones. In a number of cases it is refreshing and convincing to find out that there was no gilded Cinderella solution, although there did result a better understanding of the inherent limitations of the manufacturing process. It is of interest to note that the examples cover a wide range of products and topics, such as electrical devices, steel castings, machined parts, textiles, aeroplane components, thermostatic controls, electric cable, discrepancies of gages, overfill of containers, revision of tolerances, and so on.

As the reader goes through the pages, he is exposed to a number of fundamentals that govern the thinking of the quality control engineer as, for example: quality cannot be inspected into a product, it must be built in; some degree of variation in quality is inevitable and must be left to chance; specification tolerances should bear proper relation to the natural tolerances of the process; small sample tests cannot separate good lots from bad but as a series they can tell much about the behavior of the process; it is as important to know when to leave the process alone as to know when it should be corrected; a good sampling plan is often more effective than 100% inspection.

The reviewer has very few critical comments to make. The rule "**never under any circumstances** encourage misunderstanding by drawing the specification limits for individual values on a control chart for $\bar{X}$" is likely to be interpreted as meaning "**never** draw the specification limits," a rule to which some will find exceptions. The choice of the phrase "quality assurance of a sampling plan," referring to the operating characteristic or to specific risks of a plan, may be questioned by some. The restrictive statement that the Dodge-Romig tables are designed for use in the situation where the consumer performs the 100% inspection of rejected lots, may be the result of incomplete information, since standard practice in the use of these tables over the years has called for such 100% inspection to be performed by the producer. What is apparently overlooked is that the practice just referred to is readily accomplished by adopting a standard administration procedure; specifically by the adoption of appropriate in-plant rules of procedure, where the producer and consumer are different departments of the same company, or by the use of requirements or contractual agreements involving a system of certification with respect to producer inspections of rejected lots, where the producer is an outside concern.

In summary, this book will be found helpful to all who are concerned with the economic control of quality of manufactured products. For those who ask the question "What is this thing called quality control and is it anything I can use?", the reviewer would class this book as a "must." For the quality control engineer already well advanced in his profession, this book with its wealth of examples and practical suggestions will be enthusiastically received. And for teachers and those responsible for in-plant training programs in quality control, this book with its large number of problems to be solved will be found well suited as a text.

Review by Doris Newman, University of Buffalo

STATISTICAL QUALITY CONTROL, a working manual, summarizes the results of the study and application of statistical quality control. Professor Grant has indicated that this text is aimed at providing a general understanding of the principles underlying the various types of control charts and sampling tables—why the several methods work, how to interpret the results, and how to decide which method to use in any particular case.

The approach followed is to present first the underlying theory, where possible with an intuitive development, then to discuss the applications with examples culled from diverse fields of industrial activity. For classroom use, a series of problems appears at the end of each of the first four parts. Actual data have been used which adds to the realistic attitude towards statistical quality control that this book maintains. Advantages and disadvantages of each technique are discussed. In several instances, different methods are applied to the same data to show the comparative efficiency and costs involved. References to original sources appear in footnotes. The text is profusely illustrated with charts and diagrams and standard notation is used throughout—all of which are factors that contribute to great facility in reading the book. The presentation is non-mathematical, but adequate references are given for readers desiring mathematical rigor.

Professor Grant's book stresses the various Shewhart control charts and that portion of sampling theory important in acceptance procedures. Statistical techniques such as regression and correlation which are useful in dealing with special problems of industrial quality control have been omitted. Reference is made to general statistics textbooks containing these topics.

The book contains five parts discussing, in detail, the following topics: Part I—general aspects of control charts; Part II—elements of the theory of frequency distributions; the $\bar{X}$ and R charts, with complete directions for their use; some theory of runs; Part III—about thirty pages on the theory of probability prefacing the discussion on the control chart for fraction defective and the control chart for defects; Part IV—statistical aspects of tolerances; evaluation of quality assurance of sampling plans; single and double sampling; Dodge-Romig tables; acceptance procedures based on control charts for fraction defective, for defects per unit, and for variables. Part V is concerned with cost comparison problems involved in statistical quality con-

trol; organization for statistical quality control which considers the complex relationship between the quality control group and management, and the training program needed. The last chapter in Part V discusses the place of statistical quality control in representative manufacturing and inspection operations.

It is to be noted that the theory and interpretation of runs discussed on pages 36, 129 and 245 are not concerned with "runs" as the word is used in the current literature. In the comments on example 45, page 522, the author considers the 6003 rejects found as the total number of rejectable bolts. It appears that 6003 includes only the number of defects noted in the samples that were rejected and in detailed accepted samples. Since rejected samples were not further inspected after the number of defects leading to their rejection had been observed, 6003 cannot be the total number of defects in all lots.

Depending on the individual point of view, there may be room for additional criticism. This reviewer feels that this book will be recognized as a valuable text, and is entitled to a place in every library on statistical quality control.

O. P. R. D. REPORTS

Recently a number of requests have been received for information concerning the availability of the twelve Quality Control Reports published thru Carnegie Institute of Technology by the Office of Production Research and Development.

The supply of these reports which was available for free distribution is now exhausted. However, they may be obtained in mimeographed form from the Office of Technical Services, Department of Commerce, Washington 25, D. C., at a price of $2.00 for a complete set. Payment is to be made in advance and checks should be made payable to the Treasurer of the United States. For your convenience in ordering, please refer to report PB-27165.

LOCAL SOCIETY REPORTS

Society for Quality Control State University of Iowa Group

The new officers who took office January 1 are: President, James M. Ballowe, Aldens, Inc., Chicago; Vice-President, Wayne M. Biklen, W. A. Sheaffer Pen Co., Fort Madison, Iowa; Secretary - Treasurer, Simon Casady, Pioneer Hi-Bred Corn Co., Des Moines, Iowa. These officers will serve to June 30, 1948.

The next meeting of the Iowa Section will be held April 25-26 in Minneapolis, Minn. at the plant of the Minneapolis Honeywell Regulator Co. As guests of this company, a plant visit will be made to observe the application of the quality control installation in operation at this plant.

Following the plant visit, Mr. R. H. Colvin, Burd Piston Ring Co., Rockford, Ill., will speak on "Prediction of Individual Variation from Limited Sampling." Mr. C. W. Kennedy, Federal Products, will also address the group, explaining the latest testing equipment and its use as applied to quality control.

Milwaukee Section, American Society for Quality Control

New officers of this section for the current fiscal year are: President, Bernard Litzau, International Harvester Co., Milwaukee; Vice-President, Ernest Solun, Hamilton Beach, Racine, Secretary-Treasurer, Robert Furgason, Ladish Co., Milwaukee; new Director, Wayne Riggle, Perfex Corp., Milwaukee.

Toronto Quality Control Society

A joint meeting was held at the University of Toronto with the Chemical Institute of Canada. Dr. Grant Wernimont, Senior Physicist and Chemist of the Eastman Kodak Company of Rochester, N. Y. gave an illustrated lecture on "Statistical Quality Control in Chemical Analysis and Process Control." A number of the members of the Chemical Institute expressed their interest in the application of statistical quality control procedure to the chemical industry as outlined by Dr. Wernimont.

Saint Louis Section, American Society for Quality Control

The St. Louis Section completed its first year as an organized Society in February. In the interest shown by members and friends, and in the quality and variety of programs, it has been a successful year. Plans are now being made to continue and expand the programs and activities of this Section.

The January meeting consisted of a very interesting talk on dimensioning and the characteristics of unilateral and bilateral tolerances by Professor Burgess of Washington University. During the war, Prof. Burgess had a great deal of experience with this problem, and was able to present some unusual and useful thoughts on the subject. After the talk and discussion, the group was conducted through the former Ordnance Gage Laboratory at Washington University and the model machine shop there.

In February, at a dinner meeting, Mr. Kort Pfabe of the Carter Carburetor Corp. presented the sequential sampling plans used by his organization, and demonstrated their functioning with a box of beads.

Mr. J. H. Batchelor, Management Consultant, then gave some interesting comments on the application of a sequential plan to the problem of machine down time, and of statistical analysis to a particular plant lay-out problem.

The March meeting will be a panel discussion and open forum on the question, "Quality Control: What Is Its Value?" Various aspects are to be presented by speakers representing different industrial functions and attitudes. The speakers will be, Emil Stempsle, Works Manager, Carter Carburetor Corp.; A. C. Dickson, Chief Engineer, Emerson Electric Corp. and W. Hurley, Supt. of Inspection, Western Cartridge Co.

Delaware Quality Control Society

At the February 6, 1947 meeting, Mr. Edward M. Schrock, Quality Control Engineer, Aberdeen Proving Grounds, spoke on the subject "Fundamentals of Sequential Analysis." Mr. Schrock's talk was divided into three parts. In the first part he discussed genera' aspects of acceptance sampling, pointing out reasons for and savings possible with good sampling plans, and emphasizing requirements and limitations inherent in such plans. In the second part, he outlined and compared the essential features of standard single, double, reduced double, and sequential sampling plans for attribute inspection. The third part consisted of a detailed review of the calculations necessary in setting up a sequential sampling plan for attribute inspection. Certain advantages and limitations of sequential sampling were reviewed, particularly the possibility of quick decisions on material of very good or very bad quality and the possibility of indefinite sampling with material of borderline quality. In the latter case a decision based on technical judgment is required.

Dr. C. West Churchman, of the University of Pennsylvania, delivered a most unusual and thought provoking talk at the March meeting. Proceeding from the title of his paper, "What Controls a Quality Control System," Dr. Churchman pointed out that even when the statistical techniques are faultless, most quality control systems are themselves out of control. This is true because any quality control effort is of necessity a co-operative venture, involving a number of important variables which are usually given insufficient consideration, but which should provide a system of cross-checks on the entire project. Dr. Churchman listed those fields which he considered must necessarily be coordinated in the ideally controlled quality control set-up, and asked a number of questions to illustrate the interrelationship of these fields.

1. LOGIC. Is your quality control system used consistently?
2. MATHEMATICS. Does your system make efficient use of modern statistical methods?
3. ENGINEERING. Is your quality control really effective from the view point of the production engineer?
4. BIOLOGY. Are the people involved efficiently controlled in terms of health, etc.?
5. PSYCHOLOGY. Do the people involved have a real psychological appreciation of quality control techniques?
6. SOCIOLOGY. Do you get efficient co-operation in the political maneuvers of installing and operating statistical methodology?
7. ETHICS. At what level should quality be controlled? What do your criteria of quality really mean, particularly to the consumer?

The problems involved in psychology and sociology are critical to a good quality control system, yet they are generally given very little formal consideration.

These seven fields, and maybe others, should all cross-check one another if a quality control system is to be ideally controlled.

Western Massachusetts Society for Quality Control

The speaker at the January 17 meeting of the Society was Mr. C. W. Kennedy, Federal Products Co., Providence, Rhode Island. Mr. Kennedy's subject, "Harnessing Quality Control to the Job," was handled so as to place emphasis on the planning of quality control applications in terms of factory operations, conditions and manpower, as well as in terms of supervisory attitudes. He emphasized the fallacy of over organizing for control work and the parallel fallacy of using expensive techniques to carry out simple control operations.

Philadelphia Chapter, American Society for Quality Control

The January meeting of the Philadelphia Chapter was held in conjunction with the National Association of Cost Accountants. Mr. A. I. Peterson, Vice-President of American Society for Quality Control, spoke on the subject, "The Significance of Modern Quality Control to Management." In pointing out that the problem of quality control exists in all phases of the industrial picture, Mr. Peterson stressed the following three points: 1. Standard cost efficiency figures should be used instead of the last six month's average. Get the quality control evaluation of possibilities as to what can be maintained. 2. Analyze out all the scrap and rework costs. Pin them down to their sources. Let the foremen and men on the job fix up the troubles. 3. Seek to develop an economic understanding of quality control applications and potentialities. Mass production cannot make money unless it runs smoothly.

California Section, American Society for Quality Control

On January 21 the Section held a dinner meeting in the Banquet Room of Cole's Cafeteria in Huntington Park.

Chairman Howell gave a brief resume of National Society activities and announced the coming convention in Chicago early in June.

Mr. Edmond E. Bates of the firm Bates and Boswell gave an illustrated talk under the title "Opening Tolerances for Closer Fitting Parts." The problem concerned the control of a turned diameter on a shaft over which a ring had to fit. Approximately 50% of the parts were being scrapped. By overhauling the machine (lathe) and selecting operating personnel the operation was brought into control. Tolerances were so tight that the speed of the operation was diminished to meet tolerances. Mr. Bates demonstrated to the Engineering Section that with controlled production a .001 inch allowance between shaft and ring could be eliminated and the shaft tolerance opened up by this amount. In fact a slight overlap of shaft and ring dimensions was permitted since only four per thousand asemblies would not assemble. This enabled the tolerance on the shaft diameter to be opened up and produced a closer fit between shaft and ring. The operation could then be run at normal speed with practically no loss.

A number of guests from General Controls were present at the meeting. This is a good idea our publicity chairman, Mr. Boswell, has offered. Other Sections might make use of their meetings to introduce quality control to firms that could apply quality control techniques.

At the March 11 meeting Mr. Given Brewer, Engineering Consultant, spoke on "Strain Gages" and Mr. George Welty, Lockheed Aircraft entertained with "Weaselword Fictionary."

Society for Statistical Quality Control—Metropolitan New York Section

The January 24 meeting of the Section, held at Newark, opened with a brief business meeting after which the following papers were presented: Mr. James H. Davidson, Frick Chemical Laboratory, "The Use of Latin Squares In Industrial Statistics;" Prof. William A. MacCrehan, Jr., New York University, "Psychology Plus Per Cent Defective Packs A Punch;" Mr. Benjamin Sander, Bendix Radio Division, "Determining Specification Limits for Home Receivers;" Prof. Norbert L. Enrick, Associated Colleges of Upper New York, "Practical Use of Sequential Sampling;" Mr. Richard W. Zimmerman, Radio Corporation of America, "Rejection Probability Chart for Assemblies—Adopted from Operating Characteristic Curves;" Mr. Lyle Pitts, Federal Telephone and Radio Corp., "A Control Chart Application to Telephone Equipment;" Prof. Paul C. Clifford, Montclair State Teachers College, "A Note on Sampling by Variables;" (Editor's Note: The complete text of this paper appears on pages 12 to 15 of this issue.)

The February 28 meeting was held at the Engineering Societies Bldg. in New York. Dr. Charles McC. Mottley, Lt. U.S.N.R., spoke on "Use of Statistical Methods to Find Causes for Metallurgical Failures."

The guest speaker for the March 19th meeting was Mr. Roger I. Wilkinson, Member of Technical Staff, Bell Telephone Laboratories. His subject "Adventures with Statistics in the Jungle Air Force, from Fiji to the Philippines," illustrated with colored slides proved to be both instructive and entertaining to the large audience which assembled for dinner at the Hotel Essex House, Newark.

The next meeting of the Society will be held April 25 in New York City at the Engineering Societies Building. Mr. Howard Jones, Illinois Bell Telephone Company, will present "Sampling Plans for Verifying Clerical Work."

Syracuse Section, American Society For Quality Control

The Syracuse Section has instituted a bi-monthly training period for its members. As every other meeting is a closed meeting for members only, this time is used for the training period. The society has developed a series of eight parts dealing mostly with fundamentals of quality control, and the instructors consist of men versed in mechanics of quality control from Syracuse industry. To date, four parts have been given and have been met with much enthusiasm as this provides the only training of this nature in the Syracuse area.

On Tuesday, January 28, 1947 the monthly meeting of the society was held at the plant of the Easy Washer Machine Corp., Syracuse. Dinner at the plant was followed by a tour of the plant and a demonstration of the use of quality control in the manufacture of a washing machine. The meeting was one of the best of the current season as it was very well attended and provided an excellent opportunity for the members to see a good quality control set-up in action.

Mr. Keith E. Ross of General Electric Co., Fort Wayne, Ind., was the guest speaker at the monthly meeting held on Tuesday, February 25, 1947 at the Hotel Syracuse in Syracuse. Mr. Ross is assistant to the Director of the Product Quality Division at Fort Wayne and is responsible for the collection and study of all quality data at that plant. His topic was "Product Rejection Data; An Application of 'p' Charts in the Job Shop." Since his experience covered many applications of quality control to a great variety of products, he was able to give those attending much worthwhile information. The topic was timely and the meeting very well attended since many of the members represent industries in which job shop applications are necessary.

The April 1 meeting of the Society was an educational session in which Analysis of Variance was the topic of discussion. This session was the first of two parts on the subject and was handled by Dr. Martin A. Brumbaugh. Dr. Brumbaugh, formerly of the University of Buffalo and now with Bristol Laboratories, Inc. at Syracuse used as his topic "An Introduction to Variance Analysis." Since the Syracuse organization was mostly familiar with the usual control chart procedure, Dr. Brumbaugh explained the differences and similarities between the Control Chart method and Analysis of Variance method of attacking a problem.

Dr. Brumbaugh used a specific problem of a purchasing department receiving material from two different vendors and inspected by different men to illustrate his point. The problem was developed along the line of Control Chart methods and then by Analysis of Variance. It was found that the Analysis of Variance method gave in addition to that found by the Control Charts, Variance between testers and a refinement of the data as given by the Control Charts.

The Society was made to understand that this method of attacking a problem was one which could be used not only by experts but by any one able to do the simple mathematical manipulations such as adding, dividing, square roots, etc.

The meeting was well attended and requests were made to continue the topic at the next meeting.

Society for Quality Control Northeastern Indiana

On January 8 the Society heard Dr. Irving W. Burr, Purdue University, present "Significance of Differences." He stressed the importance of using objective tests to determine when the differences found in two sets of observations should be regarded as significant (due to assignable causes) and when such differences should be attributed to chance variability.

At the February 12 meeting Mr. E. E. Folsom, General Electric Co., Bridgeport, Conn., spoke on "Statistics as Applied to Consumer Goods." Mr. Folsom illustrated his approach with an example of the work done by the engineering department in tracking down the causes of excess variability in the time cycle of an automatic electric toaster. He then explained his quality control installation which includes machine control charts, the Dodge sampling plan for continuous production, and a quality audit plan. The latter, a unique development, is personally supervised by Mr. Folsom.

Mr. Benjamin Litzau, President of the Milwaukee Society for Quality Control, spoke briefly on the need for selling the idea of quality control to management through the cost saving resulting from decrease in substandard material, increased production, and increased tool-life.

The Ohio Section, American Society for Quality Control

A joint meeting of the Ohio Section and the American Society for Mechanical Engineers was held in January. Mr. George D. Edwards, director of quality assurance of the Bell Telephone Laboratories, and President of the American Society for Quality Control, was the guest speaker. Mr. Edwards discussed "Quality Control and What Our Societies Can Contribute to Its Advancement." In the course of his lecture, Mr. Edwards defined quality control and elaborated on the meanings and uses of its various phases. In addition, he described the organization of the national Society and gave a brief account of the aims and values of a Society of this type.

Mr. Frederick J. Halton, Deere & Company, and Dr. Martin A. Brumbaugh, Bristol Laboratories, were both guests of the Ohio Section for their February meeting. Mr. Halton discussed briefly the coming national convention in Chicago.

Dr. Martin Brumbaugh spoke on "Quality Control Proves Itself in Assembly." Dr. Brumbaugh cited actual case histories to demonstrate his point. The steps taken by various companies to achieve reduction of rejections in assembly were discussed in some detail and proved to be of considerable interest and value to the audience.

March 14 will be the date of the next meeting of the Ohio Section of the American Society for Quality Control. Mr. Wendell H. Abbott, Supervisor of Statistical Quality Control for the Lamp Department of the General Electric Company at Nela Park, will be the guest speaker. His subject will be "Some Practical Tests in Quality Control Applications." In his presentation, Mr. Abbott will cover control charts for percent defective and, in addition, tests for significance and methods for working out simple correlations. Correlations and significance tests should be a very important part of any advanced quality control program.

Buffalo Section, American Society For Quality Control

The speaker at the February 24 meeting was Mr. H. G. O'Connor, Electro Metallurgical Co. Mr. O'Connor spoke on "The Application of Correlation Techniques to Industrial Problems."

The officers for 1947 are: President, Alfred Winterhalter, Colonial Radio Corp., Vice-President, Robert Funk, American Optical Co., Treasurer, Kenneth Conrad, Du Pont Cellophane Division, Secretary, Howard Bolton, Harrison Radiator Division.

The speaker for the March 31 meeting will be Mr. Walter Oliver, Assistant Quality Control Manager at the Timken Detroit Axle Company. Mr. Oliver will talk on "Installing Quality Control." Mr. Oliver is President of the Michigan Section of the American Society for Quality Control, Chairman of the Membership Committee of the American Society for Quality Control and has a Quality Control Organization of fifty men.

Pittsburgh Section, American Society for Quality Control

The Section met on January 16 at 8:00 P.M. in Industries Hall, Carnegie Tech. The speaker was Dr. E. G. Olds, Professor of Mathematics at Carnegie Tech. Dr. Olds' subject was "Inspection Analysis by Variables." He delivered a well planned, clearly presented lecture illustrating that sampling systems can be based on variables as well as attributes, and can be used similarly to control the quality of accepted material.

Due to the unusually severe snow storms, the February 20 meeting was not well attended. However, the hardy few were well rewarded by an excellent discussion of "A Practical Application of a Test Based on Joint Relationships." Mr. Sturtevant, Development Metallurgist, Carnegie Illinois Steel Corporation, stated that such a test will forecast performance in the field. He also discussed primary, secondary and tertiary moving averages which he said they have found useful in presenting reports to management.

The Chicago Society for Quality Control

The Chicago Society announces the formation of an Assistance Committee as one of its regular standing committees with the purpose of providing information and technical assistance on quality control to industries in the Chicago area. This committee has polled the members of the Society to determine the types of quality control problems on which each is qualified to act as a consultant, and has compiled a list of firms that are willing to receive visitors for the discussion of quality control procedures. Through the coordinating efforts of the committee, firms in the Chicago area wishing to become more familiar with the advantages of quality control, or firms needing technical help on specific quality control problems, may be brought together with individuals or other firms who are willing and qualified to be of assistance. This endeavor is being undertaken in an effort to increase the use of quality control methods, and all assistance will be rendered without charge or obligation. Information regarding this program may be obtained from the Society's president, Mr. E. H. Robinson of Johnson and Johnson.

CHEMICAL COURSE

Several requests have come to the Editorial Office for information concerning courses in Quality Control which will be offered in the future. In addition to the Purdue Course announced on a previous page, word has just been received that the Rochester Institute of Technology is planning to repeat the course for the Chemical Industry in substantially the same form that it was given in June, 1946.

This would be an eight-day intensive course with emphasis on the use of control techniques in the Chemical Industries. The course is to be given at Rochester, and the tentative date is June 10-18. Persons who are interested should obtain additional information from Alfred L. Davis, Rochester Institute of Technology, Rochester 8, New York.

AMERICAN SOCIETY NEWS

CONVENTION NOTES

The Society's First Annual Convention, which will be held in Chicago June 5th and 6th, promises to be an outstanding event in the history of Quality Control. In conjunction with the Second Midwest Quality Control Conference, the Convention will include luncheon meetings on each of the two days and a dinner meeting on the evening of June 5th. Thirty-five clinical sessions will be scheduled throughout the morning and afternoon of each day and, as at last year's Midwest Conference, a group of clinics will be in session at each scheduled period.

Broad Program

Insofar as possible, the program of clinics has been designed to provide information on quality control as it applies to the various types of industrial processes. Assembly operations, forging, casting, stamping, machining, wood working, and chemical processes, as well as administrative methods, will be dealt with by one or more of the speakers. The topics chosen for discussion give wide coverage to the field of quality control.

One series of clinical sessions, designed to constitute an introductory course in statistical quality control, will be conducted by Mason E. Wescott, Assistant Professor of Mathematics at Northwestern University and Irving W. Burr, Associate Professor of Mathematics at Purdue University.

Outstanding Speakers To Appear

In addition to Professors Wescott and Burr, many other well-known scientists, engineers, and executives will address the convention. Among those who have already accepted invitations to speak or to present papers, are the following: Mr. George F. Smith, President, Johnson & Johnson; Mr. C. R. Sheaffer, President, W. A. Sheaffer Pen Co.; Mr. R. W. Jackson, President, Alden's, Inc.; Professor Edwin G. Olds, Carnegie Institute of Technology; Colonel Leslie E. Simon, Director, Ballistic Research Laboratory, Aberdeen Proving Ground; Mr. Harold F. Dodge, Quality Results Engineer, Bell Telephone Laboratories; Mr. J. B. Catlin, Assistant Technical Director, Kimberly-Clark Corporation; Mr. J. R. Steen, Director of Quality Control, Sylvania Electric Products, Inc.; Edward A. Boyan, Assistant Professor of Business Management, Massachusetts Institute of Technology, Mr. B. H. Nissen, Chief Chemist, Anheuser-Busch Brewing Co.; Professor Lloyd A. Knowler, State University of Iowa; Dr. Martin A. Brumbaugh, Bristol Laboratories; Professor Paul Peach, University of North Carolina, and many others who have had wide experience in solving difficult quality control problems.

Accommodations

The Planning Committee has done its utmost to provide for the comfort of the many members and guests who will attend the Convention. Facilities at the Hotel Sherman, where the Convention will meet, provide convenient accommodations for all sessions. The Main Ballroom for the luncheon and dinner sessions, the Main Exhibit Hall, and all clinical session conference rooms are located on the mezzanine and first floor. Conference rooms for Board and Committee meetings will be available on other floors.

Convention Reservations

The Chicago Association of Commerce and Industry has kindly agreed to handle all reservations for the Convention sessions. A preliminary program and reservation form is being mailed to each member of the American Society. Members are urged to make reservations for themselves, their associates, and guests as early as possible. Registration fee for the full Convention and Conference, including all of the clinics, both the luncheons, and the dinner sessions, is twenty dollars per person. The luncheon meeting on 5th June is being sponsored by the Chicago Association of Commerce and Industry. The evening meeting on 5th June will include the Annual Dinner of the American Society for Quality Control. Checks for registration fees should be made payable to The Chicago Association of Commerce and Industry, and should be mailed, with reservation form properly filled out, to that Association at 1 North LaSalle Street, Chicago 2, Illinois.

Hotel Reservations

The Planning Committee has reserved a large block of rooms in the Hotel Sherman for members of the Society and guests of the Convention. Hotel reservations for the period of the Convention should be made directly with the Hotel Sherman, Clark and Randolph Streets, Chicago, Illinois, reference being made to the Convention so that room assignments will be made available from among those reserved by the Committee.

Exhibits

The Exhibit Hall will contain about sixty exhibits of gauges, testing equipment, and precision measuring instruments. Some desirable exhibit spaces are still available, but it is suggested that early choice and reservation be made. Copies of the exhibit space brochure may be obtained by addressing Mr. Henry J. Becker, Exhibits Chairman, c/o American Steel and Wire Co., Waukegan, Illinois.

GRADES OF MEMBERSHIP

The Committee on Professional Ethics and Qualifications has been studying, for something over six months, questions involved in the possible desirability of professional grades of membership in the American Society. This study has involved consideration of the advantages and disadvantages of such a plan, of the favorable and unfavorable experience of other Societies with such a plan, and of the desirable qualifications for the several membership grades should they be established.

Following its study, the Committee, without dissent, has recommended to the Board of Directors that three grades of membership be established in the Society. In addition, the Committee has also recommended that provision be made for the enrollment of "Members-In-Training" in the Society.

The Committee has cited the following as among the advantages which led it to its recommendation for professional grades of membership:

1. They will provide desirable incentive goals for younger and less experienced members to work toward;
2. They will provide an additional incentive to membership in the Society for both experienced and less experienced quality control engineers;
3. They offer a possibility of ultimate reconciliation of the status of the Society with respect to the legal requirements of the several states affecting professional engineers;
4. They could be expected gradually to raise the standing of the Society, and of quality control itself, in the opinion of industry and of the public as a whole, so that its advice and counsel will come more readily to be listened to and accepted as contributive to a sound general economy;
5. Higher dues could be arranged for the successively higher grades. Dues for the younger men could thus remain low, and more of the financial support needed by the Society could be secured from the more mature members best able to provide it. This would offer additional incentive for younger ment to join;
6. Professional grades of membership offer a satisfactory solution to the problem of personal consultant advertising in the Society's journal, Industrial Quality Control.

The Committee has crystallized its recommendations by making the following concrete proposals:

a. That the qualifications for the lowest grade of membership be merely a legal age and an interest in quality control.

b. That the qualifications for the intermediate grade shall approach ultimate equivalence to the five-year experience requirement of most states for a professional engineer's license, but that this approach shall be gradual and uniform over the next three or four years.

c. That the qualifications for the highest grade shall be the ten-year experience requirement customary for the Fellow grade in other Technical Societies.

Finally, the Committee included in its proposals specific statements of the requirements for the several proposed grades, a suggested mechanism for the accomplishment of transfers, and so on.

Financing the Society

Over the past few months, it has become increasingly evident that the Society cannot continue to be operated on its present low dues scale. During its first year, substantial office, clerical and stenographic help, etc., have been contributed to the Society, which cannot be looked forward to in subsequent years. Paper and printing costs, for the magazine and for other purposes, have increased substantially. Income from "Founding Memberships" will not be available after the current year.

This whole problem was considered in detail at a meeting in the President's office in New York on 27 January, 1947. There were present a quorum of the Executive Committee, several additional members of the Board of Directors, a quorum of the Committee on Professional Ethics and Qualifications, several members of the Committee on Constitution and By Laws, and a number of other interested members of the Society.

Consideration was first given to the recommendations of the Committee on Professional Ethics and Qualifications with respect to grades of membership, and to the effect which adoption of these recommendations might be expected to have on the dues income of the Society. After substantial discussion, it was agreed that adequate income would require increased dues from all members of the Society, but that this increase should be held to a minimum ($1.00) for the lowest grade of membership. All older and more mature members of the Society should be urged to give it adequate support by transferring immediately to the highest grade to which they might be eligible.

On the basis of the above conclusions, those present at the meeting voted without dissent to recommend to the Committee on Constitution and By Laws that it include the following provisions in its new draft of the Constitution:

a. The recommendations of the Committee on Professional Ethics and Qualifications with regard to grades of membership;

b. That the three grades of membership be denominated Members, Senior Members, and Fellows, respectively;

c. That annual American Society dues for local Section members, in addition to their local dues, be as follows:

Members	$ 4.00
Senior Members	8.00
Fellows	12.00

d. That annual American Society dues for "direct membership" be as follows:

Members	$ 5.00
Senior Members	10.00
Fellows	15.00

e. That annual American Society dues for Members-In-Training be $3.00.

New Constitution

With the above as a basis, the Committee on Constitution and By Laws is hard at work on a new draft constitution, which it expects to have ready for submission to the membership for ratification by postal ballot at the time of the coming election of officers in June, 1947.

Payment of Dues for 1947-48

Dues for the two higher grades of membership will be payable in each case only after formal transfer of the individual member to a higher grade. No such transfers will be made in any event until after 1 July, 1947.

Direct membership dues for the Member grade are expected to remain at $5.00 annually as at present, and payment of such dues at this rate for 1947-48 will be accepted by the Society at any time. In case of subsequent transfer to a higher membership grade, dues already paid will be credited against those of the higher grade.

Since American Society Member grade dues for local Section members are expected to be $4.00 in 1947-48, no payments of such dues can be accepted at the old $3.00 rate. The Society will accept such payments at the $4.00 rate at any time, however. As in the

case of subsequent transfer of a direct membership to a higher grade, dues already paid will be credited against those of the higher grade.

At its meeting on 15 December, 1946, the Executive Committee approved an arrangement under which members joining the Society after 1 April need pay no dues for that fiscal year, but must, at the time of joining, pay the full dues for the next succeeding fiscal year. Members joining uder this arrangement will receive, without charge, the May issue of Industrial Quality Control for the year in which they join. Such members will have the options, however, of paying dues instead for the whole or for one-half of the fiscal year in which they join, and thus receiving all issues of the magazine for the period for which they pay dues.

In line with the above arrangement, the Society will accept, after 1 April, 1947, and covering the period until 30 June, 1948, direct membership dues of $5.00 from any prospective member, or a corresponding payment of $4.00 if made through a local Section. In either event, the membership so paid will be classified as of the Member grade upon ratification of the new Constitution.

The above arrangement will in no way affect the Founding Membership privilege, which will terminate on 30 June, 1947, and which requires a payment of at least $5.00 in addition to the dues required for ordinary membership at the time of payment of the latter.

ADVERTISING CONTRACT

Under the terms of a contract effective at the beginning of the 1947 calendar year, Richard Rimbach Associates, 1117 Wolfendale Street, Pittsburgh 12, Penna., have been appointed by the American Society as Advertising Sales Representatives for INDUSTRIAL QUALITY CONTROL.

Potential advertisers may secure rates and other information directly from Richard Rimbach Associates or from any one of their seven District Representatives whose names and local addresses and telephone numbers are listed on the Mast-Head page of the current issue of the magazine.

CHANGES IN GENERAL COMMITTEES

Committee on Membership

New England
- Paul E. Thorpe (addition)
- Lewis C. Young (resigned)

Committee on Programs and Speakers

Northern
- James M. Persons (addition)
- Irvin C. Kepner (resigned)

Committee on Publicity and Public Relations

New England
- Paul E. Thorpe (addition)
- Richard A. Page (resigned)

Mid West
- A. Fred Madaus, Regional Chairman (resigned)
- Roman M. Hammes, Regional Chairman (appointed)

NOMINATING COMMITTEE CHAIRMAN APPOINTED

The six members of the Nominating Committee, as announced in the January issue, have selected as their Chairman,

Mr. Wade R. Weaver
418-A Republic Bldg.
Cleveland, Ohio

Any member or members of the Society having suggestions as to desirable nominees for any office should communicate promptly with Mr. Weaver.

FOUNDING MEMBERSHIPS

The constitution of the American Society provides a Founding Membership in the Society, which is available to any member in good standing prior to July 1, 1947 by the payment of $5.00 or more in addition to regular dues. Certainly it is not the duty of any one to become a Founding Member. Rather, it is the privilege of all to become Founding Members. This is just about the last opportunity which the Executive Board will have of bringing this privilege to the attention of the entire membership. At July 1 the list becomes fixed and cannot be increased in any way.

JOINT A.S.Q.C.—A.I.E.E. CONFERENCE ON QUALITY CONTROL

On Tuesday afternoon, 28 January, 1947, the American Society for Quality Control participated in its first joint meeting, on a national level, with any one of the four "Founder" Engineering Societies. The occasion was a Joint Conference on Quality Control with the American Institute of Electrical Engineers, held in connection with the Winter Convention of the Institute at the Engineering Societies Building in New York City.

The first formal paper of the Conference was presented by Mr. G. D. Edwards, President of A.S.Q.C. and a Member of A.I.E.E. He discussed "The American Society for Quality Control—Its Objectives and Its Progress to Date." Mr. E. E. Folsom, Jr., Member of A.S.Q.C. and an Associate of A.I.E.E., presented the second paper on "Statistics Applied to Consumer Goods." The final paper discussed "The Application of Statistical Methods in Industry," and was presented by Mr. A. J. Winterhalter, Chairman of the Buffalo Section of A.S.Q.C.

The Conference was extremely well attended, and all of the papers were well received. An interesting discussion period followed in which, among other A.S.Q.C. members, Messrs. P. S. Olmstead, P. L. Alger, and P. C. Clifford took part.

NOTICE

The first of a series of articles relating to the Chemical Industry appeared in the January issue of INDUSTRIAL QUALITY CONTROL. A footnote to that article indicated that additional articles would appear in subsequent issues. Due to unforeseen circumstances, the second article, which was planned for this issue, was delayed. It will be presented in the May issue instead.

This temporary interruption of the series will not affect the longer range publication plan. The articles are in process of preparation according to plan with the use of quality control technique in the analytical laboratory and in control of the production process due in the next issue. Following these will come several stories of applications in specific industries. Later in the year the articles will emphasize the more advanced techniques: correlation, regression, significance tests and variance analysis.

REPRINTS AVAILABLE

The article appearing in the November, 1946 issue of INDUSTRIAL QUALITY CONTROL entitled, "A Sampling Procedure for Design Tests of Electron Tubes" by the Joint Electron Tube Engineering Council, Committee on Sampling Procedure composed of S. W. Horrocks, P. M. Dickerson, H. F. Dodge, E. R. Ott, H. G. Romig (alternate member), W. B. Rupp, J. R. Steen, R. E. Wareham, and A. K. Wright has attracted so much attention that reprints of the article have been prepared for distribution. The cost is 25 cents per copy in bulk or for single copies. Orders should be sent to Alfred L. Davis, Rochester Institute of Technology, Rochester 8, New York.

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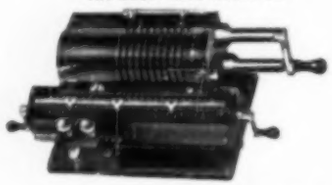

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Editorial

During the past two years, an important part of the content of INDUSTRIAL QUALITY CONTROL has been the two pages devoted to Reports of the activities of Local Societies. Although these Reports ante-date the founding of the American Society, they have taken on greater meaning and have become more representative in the past year. The Editorial Board has abundant evidence of the value of these Reports to the Societies providing the information and to other Societies through the exchange of information.

Perhaps the chief objection to the Reports has been the fact that nearly two months elapse between the time the news is sent in by the Local Secretary and the time the magazine is in the hands of readers. The difficulty may not be too apparent to lay members, but it is very real to the Secretaries and to the Editors. For example, information for the March, 1947 issue was requested as of February 20, but the January issue was not delivered until that date. Thus the Secretaries sent in Reports for March without knowing what Reports would be printed for their Societies in the January issue.

To remedy this situation and simultaneously to expand the scope of this contact between the local Societies and the national management, the Executive Committee has approved a plan whereby bimonthly bulletins will be mailed to members in lithoprinted or mimeographed form. The publication of this bulletin will be in the hands of the Publicity Committee under the chairmanship of E. H. Robinson. The Local Society Reports will appear subsequently in this bulletin. This mode of publication will remove most of the objection arising from delayed publication.

The Editorial Board takes this opportunity of expressing its appreciation of the splendid cooperation accorded by Local Secretaries Without exception, the Secretaries have responded admirably to the flow of requests for information. Sometimes it has been necessary to make major changes in the material submitted and it would be easy to guess that some of the changes may not have been fully to the liking of the Authors. If so, the objections have been completely subordinated to the broader principle of working for the common good. The Board could ask for no greater mark of approval than that the Local Secretaries will cooperate in future with Mr. Robinson and his Committee in the same way that they have worked with the Board in the past.

The request for Reports for the May issue, which would ordinarily be sent out early in April with an April 20 deadline, will not be sent from the Chairman's Office. Replacing this system will be a parallel reporting system originating in Mr. Robinson's Office. Presumably the local reporting will be cleared through the member of the local society who is a member of the American Society Publicity Committee. This matter is now in the hands of the Publicity Committee.

The space in the magazine formerly devoted to these Reports will be used in future issues for an additional technical article in some cases, while in others it may be used to bring members up to date in a department of the magazine which has in recent issues been completely neglected; namely, the presentation of bibliographies of articles appearing currently in other magazines. An attempt has been made to review leading new books in the quality control field, but even here the coverage has been considerably less than the Board would have desired if means had been at hand to overcome the fault.

McGraw-Hill Books of Timely Importance

STATISTICAL QUALITY CONTROL

By Eugene L. Grant, Stanford University. *McGraw-Hill Industrial Organization and Management Series.* 563 pages, $5.00.

This distinctive book deals with the laws of probability that may be used to improve acceptance procedures and thus secure the best possible quality assurance from a given inspection cost. Explains the Shewhart control chart, its use in manufacturing to reduce costs of spoilage and rework, and to obtain a better coordination between design, production, and inspection. The careful explanation of basic principles is accompanied by many practical examples demonstrating the broad usefulness of quality control techniques in dealing with quality problems in mass production.

SELECTED TECHNIQUES of STATISTICAL ANALYSIS

For Scientific and Industrial Research and Production and Management Engineering.

By the Statistical Research Group, Columbia University. 42 pages, $6.00.

Discusses a series of problems frequently encountered in planning, analyzing, or interpreting quantitative data, and explains various techniques appropriate to these problems. Expounds the statistical approach to a problem, the theory that can be brought to bear upon it, and points out the features of the problem that determine the relevance of the theory. Gives detailed computational procedures, and illustrates the interpretation of the results.

SAMPLING INSPECTION

By the Statistical Research Group, Columbia University. 393 pages, $5.25.

Gives principles, procedures, and tables for single, double, and sequential sampling in acceptance inspection and quality control based on percent defective. The elementary concepts of acceptance sampling are carefully treated, a standard sampling-inspection plan is supplied, and detailed instructions are given so that the principles developed and plans supplied can be used for practical inspection of industrial products. Much of the material has not previously been published.

CONTROL CHARTS

By Edward S. Smith, University of Cincinnati. *McGraw-Hill Industrial Organization and Management Series.* Ready in May.

A text on the purposes, construction, and interpretation of the charts of statistical quality control, intended primarily for men in industry. The treatment is simple, and practical applications are emphasized rather than the development of mathematical formulas. The charts are developed gradually, with careful explantations and clear diagrams. An unusual feature is the simplified, nonmathematical, yet detailed treatment of frequency curves and their value in interpreting statistical data.

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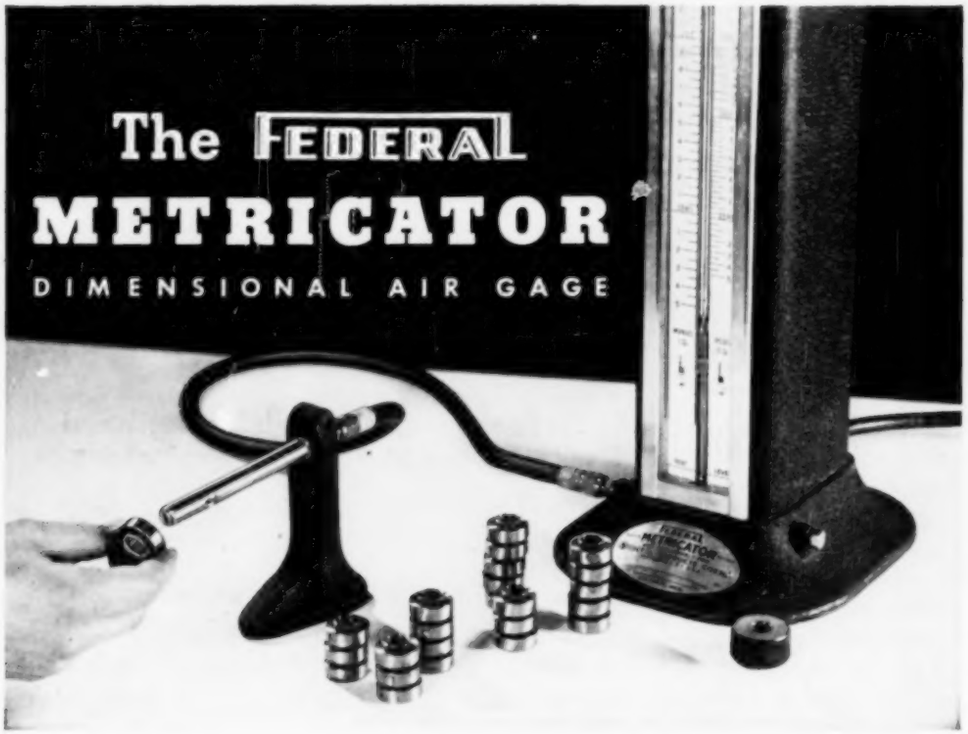

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